

HEALTH, RISK, AND ENVIRONMENTAL JUSTICE
FOR INDIGENOUS SHELLFISH HARVESTERS IN BRITISH COLUMBIA, CANADA

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By

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ABSTRACT

My master's thesis explores the connections between health, risk, and environmental justice related to Indigenous shellfish harvesting in British Columbia, Canada. I explore clam gardens, a type of cultural beach modification that enhances clam production and harvest, to examine human, animal, and ecosystem health connections using the One Health framework. My analysis reveals a multitude of interconnectivity, where clam gardens can promote concurrent health benefits for Indigenous peoples, clams, and the ecosystem. Clam gardens support human health on individual, social, and community levels by promoting physical activity, connections with the land, intergenerational sharing of culture and knowledge, food security, autonomy, sovereignty, and self-determination. Clam gardens support animal health by providing optimal clam habitat enhancing clam growth rates, density, and biomass; and ecosystem health by modifying habitat to benefit other species. These interconnections also present challenges where threats can impact health within and across domains, making appropriate consideration of health connections essential for risk management.

Risk management is linked to environmental justice, which includes equity of risk distribution, recognition of diversity of people and experiences, and participation in environmental policy creation and management. Indigenous environmental justice also involves a recognition of their rights to self-determination, autonomy, their lands, and cultural practice and development. To investigate a real-life example, I examined whether the Canadian risk management system for paralytic shellfish poisoning is environmentally just for Indigenous shellfish harvesters. I created and applied a framework on environmental justice related to risk management systems and determined that improvements are required for the system to be more supportive of Indigenous environmental justice. Four recommendations for improvement are: 1) increasing collaboration with affected people; 2) expanding and/or modifying monitoring; 3) including Indigenous traditional knowledge to guide decision-making; and 4) recognizing Indigenous peoples' rights to self-determination and autonomy. I also highlight steps Indigenous communities can take to improve environmental justice: creating and submitting draft amendments for the Canadian Shellfish Sanitation Program; attending Pacific Regional Interdepartmental Shellfish Committee meetings and developing strong working relationships with Canadian Shellfish Sanitation Program members; and applying under the Canadian Shellfish Sanitation Program for new area classification, monitoring sites, and to be monitoring partners.

My project was conducted from an outsider perspective, which may vary from perspectives held by Indigenous peoples. My results provide information about health connections that can be used by decision-makers in clam garden revitalization projects, and offer recommendations for members of the Canadian Shellfish Sanitation Program and Indigenous communities on how to improve environmental justice related to paralytic shellfish poisoning risk management.

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DEDICATION

For Tahini

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LIST OF ABBREVIATIONS

BC: British Columbia, Canada

CFIA: Canadian Food Inspection Agency

DFO: Department of Fisheries and Oceans Canada

ECCC: Environment and Climate Change Canada, formally Environment Canada

EJ: Environmental justice

GINPR: Gulf Islands National Park Reserve

HTG: Hul'qumi'num Treaty Group

ISC: Interdepartmental Shellfish Committee

MPN: Most probable number

NISC: National Interdepartmental Shellfish Committee

OH: One Health

PRISC: Pacific Regional Interdepartmental Shellfish Committee

PSP: Paralytic shellfish poisoning

RISC: Regional Interdepartmental Shellfish Committee

UNDRIP: United Nations Declaration on the Rights of Indigenous Peoples

TRC: Truth and Reconciliation Commission

1. INTRODUCTION

1.1. Summary

For many coastal communities, including Pacific Coast Indigenous peoples, practices associated with shellfish harvest and consumption are immensely important to culture, food security, holistic health, individual and community relationships, and local economies. To further examine the relationship with holistic health, I explored the human, animal, and ecosystem health connections in clam gardens. Clam gardens are a type of beach modification used by some Indigenous peoples to produce optimal conditions for clam growth and survival, and facilitate clam harvest. I used the One Health framework to synthesize the emerging literature on clam gardens to explore connections between Indigenous peoples, clams, and the ecosystem. My results indicate that multiple connections exist where clam garden activities can simultaneously improve health in all domains. Clams have nutritional, cultural and economic importance where clam gardens help improve individual and community health by providing a forum for reconnecting with the land and traditional knowledge, cultural expression, intergenerational knowledge sharing, and ecosystem rehabilitation. Clam gardens also require a group effort to provide a culturally appropriate food source, thus, improving community food security, autonomy and cohesion. Construction, maintenance, and harvesting techniques improve clam growth and survival, while enhancing ecosystem health by increasing biodiversity, creating new and improved habitat, and impacting nutrient cycling. However, the health connections can also produce challenges, for example, where a health threat can simultaneously cause harm in all health domains. To safeguard holistic health between domains, risk management systems require consideration of health connections and overall impacts on factors producing health benefits.

To further examine how risk management system currently operate in the context of coastal British Columbia shellfish harvests, I used the example of paralytic shellfish poisoning (PSP), a serious public safety concern resulting from consumption of shellfish contaminated with toxic algae. Risk management is intricately connected to environmental justice (EJ), where decisions regarding risk management systems can influence distribution of risk, extent of diversity of people and experiences considered, and who gets to participate in policy creation and management. For Indigenous peoples, design of risk management systems can also influence whether their rights to self-determination, autonomy, their lands, and culture are respected.

Specifically, I sought to determine whether the Canadian risk management system for PSP is environmentally just for Indigenous shellfish harvesters. I did so by creating a framework capable of exploring EJ related to risk management systems based on the literature. I applied the framework to PSP risk management and determined that the Canadian Shellfish Sanitation Program (CSSP) requires changes to improve and promote EJ for Indigenous shellfish harvesters. Recommendations for improvements to the CSSP that derive from this exercise are largely associated with recognizing Indigenous peoples' rights to self-determination and autonomy, such as increasing meaningful collaborative participation with Indigenous communities, improving/expanding monitoring, and including Indigenous traditional knowledge as an information system to inform risk management.

I also make recommendations for Indigenous shellfish harvesters to help increase their level of EJ within the current system. These recommendations include: creating and submitting draft amendments for the CSSP; attending and participating in Pacific Regional Interdepartmental Shellfish Committee meetings and developing strong working relationships with CSSP members; and applying under the CSSP for new area classification, monitoring sites, and to be monitoring partners in areas where shellfish harvesting occurs.

1.2. Introduction

For many coastal communities, shellfish have played a major role in culture, history, community cohesion, food security, and economy, and continue to shape lives and a way of being (Keith et al., 2016; USEPA, 2018). This holds true in numerous Indigenous and non-Indigenous communities in coastal British Columbia (BC). The Government of BC recognizes the importance and potential of the shellfish industry, particularly for its positive impact on the economy. In 2016 alone, the total volume of shellfish harvested was 23,600 tonnes, with a landed and wholesale value of CAD \$143 million and CAD \$269 million, respectively (AgriServiceBC, 2016). Thus, the Government aims to strengthen the industry by supporting sustainable harvesting practices, promoting value added products, and increasing access to domestic, inter-provincial, and international markets (AgriServiceBC, 2015).

For coastal Indigenous communities, the importance of shellfish include and go far beyond the benefits to the economy. Shellfish strongly influence way of life and are a core component of holistic health, supporting diet and nutrition, cultural traditions and interactions with the land, food security, and community cohesion (Deur et al., 2015; Donatuto, 2008; Harrison & Loring, 2016; Silver, 2014). Various species are harvested using multiple techniques that have been optimized and/or modified over the years to adapt to changing environmental and sociopolitical situations (Deur et al., 2015; Groesbeck et al., 2014; Silver, 2014).

Clam gardens are one example of a unique, local shellfish management system that produces beneficial outcomes for humans, animals, and the environment (Deur et al., 2015; Groesbeck et al., 2014; Jackley et al., 2016; Lepofsky et al., 2015; Lepofsky & Caldwell, 2013). Clam gardens rely on beach modification techniques used for over 1,500 years on the Pacific Coast of North America. They are constructed by building a rock wall at the low tide line along beaches in bays and coves, which allows sediment accumulation on the landward side resulting in creation of optimal growing conditions for clams (Augustine & Dearden, 2014; Deur et al., 2015; Groesbeck et al., 2014; Harper et al., 1995; Jackley et al., 2016; Lepofsky et al., 2015; Moss & Wellman, 2017; Neudorf et al., 2017). Although use diminished following European contact, there are new efforts to revitalize former clam gardens (Augustine & Dearden, 2014; Deur et al., 2015). For example, in the Gulf Islands National Park Reserve (GINPR), a collaborative project involving the Hul'qumi'num Treaty Group (HTG), WSÁNEĆ First Nations, and Parks Canada is occurring to restore two historical clam gardens in an effort to improve ecological enhancement for shellfish, while promoting Indigenous cultural practices and food security (Bouevitch, 2016). Considering the importance of clam garden revitalization projects, an examination of the various health connections between Indigenous peoples, clams,

and the environment would help inform decision-makers, promote sustainable management of projects and identify potential risks to people, animals and ecosystems.

Shellfish harvesters face many challenges that threaten harvesting opportunities, quality, safety, and holistic health benefits. For example, environmental contaminants threaten food safety associated with shellfish consumption, which impacts harvesting and consumption activities (CFIA, 2019). Some environmental contaminants are anthropogenically caused, while others are naturally occurring. Paralytic shellfish poisoning (PSP) is a condition that occurs when shellfish contaminated with specific types of naturally occurring algal toxins are consumed. The toxins block nerve impulses potentially resulting in muscle paralysis, which can lead to respiratory arrest and death (DFO, 2015; Halstead & Schantz, 1984; Wekell et al., 2004). Considering both the potential severe consequences of environmental contaminants and the importance of shellfish harvesting, appropriate risk management is essential to ensure concurrent public safety and support for shellfish harvesting.

For the purposes of this thesis, risk is defined as “the perception of the probability and magnitude of some future adverse event” (Adams, 1995, p.180). Risks are generally viewed only for the negative consequences of risk-taking behaviour, which influences the societal desire/obsession to reduce risk. However, there are many positives associated with risk-taking that need to be considered alongside the negatives to ensure risk management supports health promotion in a holistic sense (Adams, 1995). To appropriately balance the positives and negatives to maximize benefits, risk management design and implementation is most effectively done in collaboration at governmental and local levels (for example, Corburn, 2002; Kriebel et al., 2001; Loring & Duffy, 2011). Considering the participation and knowledge required to achieve this balance, and the potential negative implications of risk management systems that do not meet this target, the concept of EJ becomes intricately associated with risk management. Here, EJ involves equity of risk distribution, consideration of diverse people and experiences, and participation in environmental policy and management, whereas Indigenous EJ also includes respecting rights to self-determination, autonomy, lands, and culture (Agyeman et al., 2002; Bullard, 1996, 2001; Bullard & Wright, 1993; Checker, 2007; Loring & Duffy, 2011; O’Neil, 2003; Schlosberg, 2004; Schlosberg & Carruthers, 2010; Tsosie, 2007; UN, 2007). EJ associated with risk management systems related to environmental contaminants have not been evaluated for their impact on Indigenous shellfish harvesters. Information resulting from such an examination would help create/modify current risk management systems to better support health promotion and Indigenous EJ.

1.3. Objectives and Methods

This thesis has two overarching objectives: 1) to discuss the myriad health connections among Indigenous peoples, clams, clam gardens, and coastal ecosystems, and 2) to evaluate the current PSP risk management system for shellfish harvests from a perspective of EJ. For this work, I employed two methods:

Method 1: I synthesized the emerging literature on clam gardens within the One Health (OH) framework to describe human, animal, and ecosystem health connections. A OH lens was established by synthesizing the literature relating to the application of and approach to OH.

There is limited research on clam gardens; therefore, the goal of my clam garden literature review was to investigate all published literature on clam gardens.

Method 2: I synthesized the literature on risk and EJ to create a framework capable of evaluating risk management systems as they relate to EJ. I then applied my framework to PSP risk management in reference to Indigenous shellfish harvesters. The main document used to evaluate the Canadian PSP risk management system was the Canadian Shellfish Sanitation Program (CSSP) manual of operations.

1.4. Chapter Overview

My second chapter describes connections among Indigenous people, clams, and ecosystem health in clam gardens. The OH framework was chosen as a heuristic for exploring the nature and extent of health linkages in clam gardens as a social-ecological system. I introduce the framework as well as my rationale for choosing OH over related frameworks. I describe the connections between the three health domains by providing a definition of health, health status summary, and description of health connections in the clam gardens for Indigenous people, clams, and the ecosystem.

The third chapter investigates whether the Canadian risk management system for PSP is environmentally just for Indigenous shellfish harvesters. I provide background information on risk, EJ, PSP, and the CSSP. I synthesize the literature on risk and EJ to create a framework suitable to investigate whether a risk management system supports Indigenous EJ. I then apply the framework to PSP risk management as it relates to Indigenous shellfish harvesters.

Finally, in my conclusion, I seek to draw some insights from across the two chapters to discuss means to rethink health, risk, EJ, and risk management systems to promote greater accommodation for traditional land interactions within a colonized framework.

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2. HUMAN, ANIMAL, AND ECOSYSTEM HEALTH CONNECTIONS IN CLAM GARDEN REVITALIZATION PROJECTS

2.1. ABSTRACT

Understanding human-animal-ecosystem health connections in communities and ecological systems can help develop management strategies that support win-win solutions within and between the three health domains. I use clam garden revitalization by Indigenous peoples in British Columbia, Canada as a case to explore the various health connections in a win-win ecological scenario. This information may be useful to help understand the roles that people can play in stewarding local ecosystems through activities generally thought of as ‘extractive’, e.g. wild food harvests. I used One Health from an outsider perspective as a heuristic framework to explore health connections between local people, clams, and the ecosystem. Clam gardens support human health on individual, social, and community levels by promoting physical activity, connections with the land, intergenerational cultural interaction and knowledge sharing, food security, autonomy, sovereignty, and self-determination. Likewise, the acts of building and maintaining clam gardens support animal health by providing optimal clam habitat that enhances clam growth rates, density, and biomass, and enhances ecosystem health by modifying habitat in a way that also benefits other species. Bivalves have positive and negative impacts on community composition, and their management affects ecosystem quality. My results show that clam gardens have and support a multitude of important health connections. These connections benefit humans, animals, and the ecosystem, but also foster vulnerabilities that need to be addressed through careful management.

KEYWORDS: clam gardens, health connections, Indigenous health, clam health, ecosystem health

2.2. INTRODUCTION

The connection between our people and the land is fundamental to the Hul’qumi’num Mustimuhw’s cultural identity and way of being. Our oral history and customary laws teach us that we are not of the land, we are the land and its resources (HTG, n.d.)

Important connections between humans and ecosystems have long been recognized within the worldviews and practices of many cultures, particularly Indigenous cultures (Durkalec et al., 2015; Loring & Gerlach, 2009; Richmond & Ross, 2009). These close, often intimate interactions and dependencies often contribute to a mutualistic relationship, wherein social and environmental outcomes trend together, towards either wellness and sustainability or disease and degradation (Loring et al., 2016). Although paradigms in natural resource management have historically interpreted the relationship among people and nature as zero-sum, where either humans or ecosystems benefit at a cost to the other (e.g., Rees, 2010), a shift in environmental thinking has occurred to prefer win-win ecological solutions, where humans meet their needs while promoting ecosystem health (Augustine & Dearden, 2014; Loring et al., 2016; Rosenzweig, 2003). For example, Loring et al. (2016) proposed the notion of ‘sentinel communities’, where human well-being is tightly linked to ecosystem health, and as a result,

people are empowered to steward local resources sustainably. To support and better develop their proposition, Loring et al. (2016) called for further empirical investigations of the connections between human and ecosystem health, particularly in and with communities that are intricately connected to their local environment.

Following this call, I use the resurgent practice of clam gardens by Indigenous peoples in British Columbia, Canada, as a case to explore how human and ecosystem health are linked, and how people are trying to rebuild and strengthen those relationships. I build on the proposition of Loring et al (2016) by including animal health as an important and interconnected third component of the overall health picture, and chose One Health (OH) as the framework to explore connections between the three health domains in the clam gardens (Lapinski et al., 2015; Wolf, 2015). This review will include: first, a general description of clam gardens, their history, and how they are being revitalized by Indigenous people of British Columbia; second, a description of OH and why it was chosen over other related frameworks; and third, an examination of clam gardens through a OH lens by providing a health definition, health status summary, and description of health connections between other health domains for Indigenous people, clams, and the ecosystem. Since I did not work directly with community members during this project, I recognize that my outsider perspective comes with biases from my own life experiences, which influences my interpretation of health across and within the three health domains that may differ from those of Indigenous peoples in the area. My work contributes to clam garden management by synthesizing and describing human, animal, and ecosystem health connections, which can inform decision-making to support revitalization projects into the future. My work also contributes to holistic OH application by utilizing the framework in a social science context related to Indigenous health.

2.3. METHODS

I used OH from an outsider perspective by synthesizing the literature on clam gardens through a OH lens with an emphasis on research focusing on clam gardening by people of coastal British Columbia. The OH framework as generally applied describes: the people, animal(s), and ecosystem in the case in terms of health, and how the connections between these three health domains are or can be impacted by an offending agent (see, for example, Destoumieux-Garzón et al., 2018; Jariwala et al., 2017; Mazet et al., 2009; Paternoster et al., 2017; Rüegg et al., 2018). In most OH literature, an offending agent is usually one that causes disease in humans and/or animals; however, it can include other factors in holistic OH approaches (e.g. land-use practices, economic policies, and climate change) (see below for a discussion on holistic OH). Since my review does not consider the effects of a particular offending agent, I primarily use the language of OH as a heuristic for exploring how humans, animals, and the ecosystem are independent and connected entities within a system.

Since the emerging literature on clam gardens is relatively limited, the goal of the literature search was to examine all sources on clam gardens. I searched Google Scholar, Web of Science, and Scopus in February of 2018 with the search term ‘clam gardens’, which is a fairly ubiquitous terminology in the study area. This yielded 62 papers of which 10 were within the scope of the review, since they were the only ones relating to Pacific Coast clam gardens. I also

used one additional reference on clam gardens from the bibliographies in sources from the original search. This source was not found in the original search because the author used the term ‘clam terrace’ instead of ‘clam garden’. A similar search was conducted using ‘clam terrace’ revealing no additional sources.

2.4. BACKGROUND

2.4.1. Clam Gardens

Clam Gardens are a form of cultural beach modification historically practiced by coastal Indigenous peoples to increase shellfish production and harvest (Augustine & Dearden, 2014; Deur et al., 2015; Harper et al., 1995). They are found in Northwest North America, from Washington to Alaska, and were usually constructed in semi-protected inlets by building a rock wall at the low tide line across a bay or cove. The wall permitted deposition of fine sediment on the landward side, creating a gradually sloping terrace (see Figure 2.1. and 2.2.) (Augustine & Dearden, 2014; CGN, n.d.; Deur et al., 2015; Groesbeck et al., 2014; Harper et al., 1995; Jackley et al., 2016; Lepofsky et al., 2015; Moss & Wellman, 2017). Maintenance of clam gardens involved selectively harvesting large clams; aerating the sediment using a digging stick and rock rolling; removing recently placed or uncovered rocks and large clam shells; adding gravel and crushed clam shells; and excluding competitors and predators (Augustine & Dearden, 2014; Deur et al., 2015; Groesbeck et al., 2014). Four species of clams were principally harvested: littleneck clams, *Protothaca staminea*; horse or ‘gaper’ clams, *Tresus nuttallii*; butter clams, *Saxidomus giganteus*; and cockles, *Clinocardium nuttallii* (Deur et al., 2015).



Figure 2.1. Clam Gardens shoreline view



Figure 2.2. Clam Gardens offshore view

Photo credits: Phil Loring

The gardens are thought to have been governed using social rules that would maximize community benefits and health (Lepofsky et al., 2015; Lepofsky & Caldwell, 2013; Moss & Wellman, 2017). Construction and maintenance created optimal habitat for clam growth and productivity, while promoting social and cultural ties, food security, and economic stability (Deur et al., 2015; Groesbeck et al., 2014; Jackley et al., 2016). Use and maintenance of clam gardens diminished following European contact, likely because of various factors, including human population decline from epidemics and dislocation; culture and labour loss associated with settler government policies including residential schools; changing food choices; and loss of

access to traditionally used beaches. Today, clam gardens range from being consistently maintained and harvested to unused for generations (Augustine & Dearden, 2014; Deur et al., 2015).

There are currently a handful of cases where communities are actively working to restore clam gardens and traditional beach management practices. Among these is one located in the Gulf Islands National Park Reserve (GINPR), a collaborative initiative of the Hul'qumi'num Treaty Group (HTG), WSÁNEĆ First Nations, and Parks Canada to restore two historical clam gardens in Fulford Harbour, Salt Spring Island. The goal of the project is to determine whether traditional marine stewardship practices can support ecological enhancement for shellfish in the GINPR, while simultaneously strengthening Indigenous food security and cultural practices (Bouevitch, 2016). Research indicates that clam gardens improved resilience and health of past Indigenous communities, while concurrently increasing clam biomass and density compared to non-walled beaches (Deur et al., 2015; Jackley et al., 2016). Thus, clam garden revitalization projects are examples of community-directed ecological stewardship that seek to support community and ecosystem health, food security, coastal biodiversity, heritage reclamation, and self-governance (Lepofsky et al., 2015).

2.4.2. One Health

One Health is an interdisciplinary framework that seeks to formally acknowledge and model the interdependence of human, animal and ecosystem health (Lapinski et al., 2015; Wolf, 2015). The framework has a veterinary-public health origin and is used to assist development of a system-level understanding of factors affecting health outcomes to influence health management decision-making, particularly in situations involving infectious diseases (Papadopoulos & Wilmer, 2011; Zinsstag et al., 2011). Although a narrow focus of OH is limited to human and veterinary medicine considerations, there has been an expansion of OH to adopt a more holistic focus that includes other aspects of health, such as food security, economics, community participation, and social behaviours (see figure 2.3) (OH Congress, 2011; Hinchliffe, 2015; Hueston et al., 2013). OH is growing in popularity to approach local, national, and global health concerns, since it focuses on realizing the important interdependencies of all three health components (Hinchliffe, 2015; Okello et al., 2011). It is arguably a framework that can support initiatives for both understanding and designing win-win solutions that simultaneously support and improve human and ecosystem health.

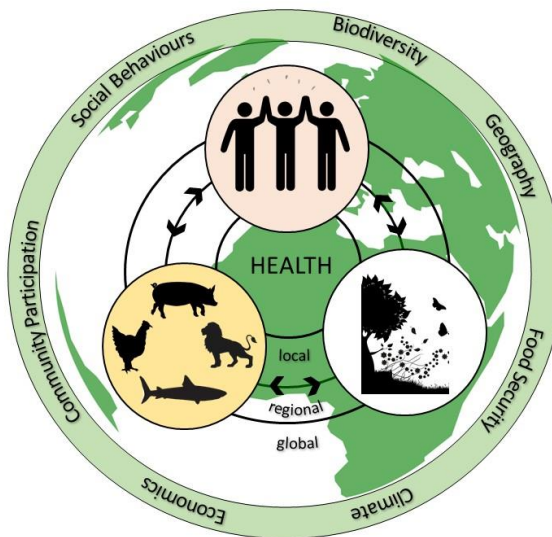


Figure 2.3. Holistic One Health (Scholten, n.d.)

Other frameworks exist in academic research that are similar to OH; perhaps most notable are Planetary Health and Ecohealth. Planetary Health is concerned with the global attainment of the highest standard of human health, wellbeing and equity through political, economic and social systems, and the state of natural systems upon which human life depends (Whitmee et al., 2015). One important difference between Planetary Health and OH is that the former emphasizes human health over the other health domains, and in practice, has been less interdisciplinary than OH and EcoHealth (Lerner & Berg, 2017). Ecohealth is a framework involving human, animal, and ecosystem health that includes considerations for environmental sustainability and socioeconomic stability (Lerner & Berg, 2017). Ecohealth has a strong emphasis on equality between the three health domains as well as on the inherent value of biodiversity where all living creatures have value and should be protected, including parasites, viruses, and bacteria. Ecohealth accepts the principle that health and well-being depend on resource availability, an unpolluted environment, and social stability (Lerner & Berg, 2017). When a holistic approach to OH is taken, there are arguably few differences among OH and Ecohealth, and as such, some authors argue for a merger between the two frameworks (Lerner & Berg, 2017; Roger et al., 2016; Zinsstag, 2012). I chose to use the holistic OH framework because it examines human, animal, and ecosystem health connections using a broad concept of health, and to support its growing popularity in cases other than those involving infectious diseases.

2.5. CLAM GARDENS THROUGH A ONE HEALTH LENS

2.5.1. Contemporary Indigenous Health Challenges in Canada

The World Health Organization defines health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 1946). In addition to recognizing this definition, many Indigenous communities view health holistically with humans being interdependent and inseparable from all else through a physical, emotional,

intellectual, and spiritual connection. This connection means individual health cannot be understood in isolation of community, the land, and animals. Health involves knowledge transmission and practice of traditional teachings, culture, and language; community cohesion; and food security (CSDH, 2007; Donatuto, 2008; King et al., 2009).

In Canada, numerous historical and contemporary assaults on Indigenous people's health have resulted in alarming health disparities (CMA, 2002; Durkalec et al., 2015; JOGC, 2013; Richmond & Ross, 2009). Indigenous people are more likely than non-Indigenous Canadians to suffer from conditions such as obesity, type 2 diabetes, cardiovascular diseases, regular heavy drinking, and mental disorders associated with substance abuse (Garriguet, 2004; Gracey & King, 2009; Harper et al., 2013; Lix et al., 2001). Furthermore, poverty, unemployment, unsafe housing, inadequate sanitary infrastructure, and food insecurity are more common in Indigenous communities, with women carrying a higher burden from these stressors (Gracey & King, 2009; JOGC, 2013). Children, the future of Indigenous communities, experience increased rates of neonatal complications including mortality and diseases like tuberculosis; obesity and diabetes; injuries; and have higher rates of suicide. They are also more likely to be exposed to low socioeconomic status, substance abuse, and the child welfare and criminal justice systems (Greenwood & de Leeuw, 2012; JOGC, 2013; Sinha et al., 2013).

Causes of these health disparities are multi-faceted and complex, with the majority stemming from historical and contemporary impacts of colonialism (CSDH, 2007). A major impact of colonialism was the disruption or severance of connections to the land, which prevented practice and teaching of culture, traditional economy, and food security (CSDH, 2007). This disruption was achieved through means such as land disappropriation, environmental pollution, the reservation system, and limiting access to culturally significant areas, for example through land privatization and poverty (CSDH, 2007; Donatuto, 2008; Greenwood & de Leeuw, 2012). Moreover, the residential school system significantly affected and continues to affect the health of Indigenous people. The residential school system aimed to "kill the Indian in the child" (TRC, 2015) and involved forcibly removing Indigenous children from their families and communities, physical and sexual abuse, denunciation of culture and identity, exposure to deplorable living conditions, and a general deprivation of love required by all children (King et al., 2009). The impacts of this experience resulted in carryover of abuse, and a loss of culture, language, knowledge of traditional food and economy, and parenting skills (Kirmayer et al., 1996). The many additional impacts of colonialism are beyond the scope of this paper.

Numerous methods to improve these health disparities have been pursued, with self-determination and empowerment for Indigenous people being essential central components. Other recommendations include reconnecting with the land and traditional knowledge, restoring land rights and cultural heritage, rehabilitating ecosystems, economic redistribution, and dealing with racism (CSDH, 2007). Developing food security is also essential for supporting Indigenous health (Loring & Gerlach, 2009). Food security for Indigenous people is more than just access to sufficient, safe and nutritious food, it emphasizes the importance of highly nutritious country foods, cultural expression through harvest, and respect for animals and ecosystems on which all life depends (Power, 2008; WFS, 1996). Harvesting country foods is important for connecting to

the land, and exercising and sharing cultural practices (RCAP, 1993). Country food systems are an important connection between human and environmental health, and provide a cultural forum for social participation, cohesion, and integration (Power, 2008; Willows, 2016).

Increasing environmental, social and political pressures are disproportionately threatening food security in many Indigenous communities in Canada (Loring & Gerlach, 2015). These pressures decrease access to, and increase health risks associated with country foods; encourage Indigenous people to choose store-bought over country foods; and interrupt intergenerational knowledge sharing about the benefits of traditional diets and the means to obtain country foods (Loring & Gerlach, 2009; Socha et al., 2012). When barriers are removed for access to country foods and reconnecting with the land, Indigenous people have had great successes with healing through traditional means (Durkalec et al., 2015; Robbins & Dewar, 2011).

2.5.2. Impacts on Human Health

Many Indigenous people engaged in clam garden revitalization projects are actively pursuing ways to reconnect their physical, psychological, and sociocultural health with their traditional lands. For example, the Hul'qumi'num people describe their world view as including a recognition of spiritual relationships with the environment, appreciating a need for appropriate management of resources and human behaviour in balance with needs, including spiritual needs, of the environment (HTG, n.d.). However, the effects of colonialism have created numerous social and economic challenges that make such initiatives in cultural revitalization difficult (HTG, n.d.; Morales, 2006). The HTG Land Use Plan (2005) stresses the importance of maintaining connections to the land to support social, cultural and economic needs, and that these connections are inseparable from environmental health (Bouevitch, 2016). When discussing intertidal ecosystem health, the Hul'qumi'num people generally believe that greater health is achieved through active traditional management practices, and are unsupportive of conservation initiatives that prevent Indigenous access and use (Ayers et al., 2012). Barriers to traditional harvesting practices that have limited the ability of Hul'qumi'num people to participate in active beach management include: privatization of land and resources; government management and enforcement structures; poverty and inadequate resources; environmental health concerns; and lack of traditional knowledge (Fediuk & Thom, 2003; HTG, Evans et al., 2005). Despite adversity, the Hul'qumi'num people, like many Indigenous people, remain strong and determined to improve community health and defend their traditional territories and ways of living (Donatuto, 2008; HTG et al., 2005; Morales, 2006).

Seafood is a core component of health and culture for Indigenous peoples throughout coastal Northwest North America, nourishing the physical being and ties to community and the land (Donatuto, 2008). Although salmon receives the most significant attention in research, clams were also extremely important for Indigenous peoples on the Northwest Coast nutritionally, culturally, and economically (Deur et al., 2015; Kuhnlein & Humphries, n.d.). Nutritionally, clams are a source of many health promoting factors including proteins, omega-3 fatty acids, Vitamin B-12, and various essential minerals (Hamed et al., 2015; Moll & Davis, 2017). Clams were dietary staples, used during times of decreased access or availability of other

country foods, and were prepared in several ways for immediate consumption or preserved for later use (Deur et al., 2015; Kuhnlein & Humphries, n.d.).

Culturally, clams have deep reverence in many coastal Indigenous communities. For example, in Coast Salish culture, clams are considered by many to be a distant but important relative to people, having families and social structures similar to humans (Deur et al., 2015; Kuhnlein & Humphries, n.d.). Clams often play considerable roles in important cultural stories. For example, the Maiden of the Sea, who protects fishermen in Coast Salish culture, is believed by some to be a young girl turned clam-person when caught digging clams during the rising tide (CGN, n.d.; Kuhnlein & Humphries, n.d.). Furthermore, clams are a focal and essential component of various ceremonies and annual gatherings (Donatuto, 2008; Kuhnlein & Humphries, n.d.). In addition to clam flesh, shells had many uses such as to make decorations, jewelry, and culinary tools including spoons, ladles, containers, and cups. Shells were also used as tools to scrape bear hides and cambium from tree bark, in house platform construction, to in-fill wetlands and improve drainage, and to improve nighttime visibility of paths (Deur et al., 2015; Kuhnlein & Humphries, n.d.; Mathews & Turner, 2017).

Economically, clams were likewise extremely important for trade capacity. Clams helped coastal Indigenous communities acquire desired resources such as berries, root vegetables, herring eggs, and eulachon oil. Following European contact, some Indigenous communities used clam gardens as an inroad into the cash economy, selling clams to help feed communities and maintain traditions (Deur et al., 2015). Today, commercial clamming is an important source of income in many Coast Salish communities (HTG et al., 2005).

Considering the multifaceted significance of clams to coastal Indigenous peoples, clam gardens offer an important means to increase clam productivity and ease of harvest, while simultaneously providing several human health benefits on individual, social and community levels (Deur et al., 2015; Groesbeck et al., 2014). For individual health, the construction, maintenance and harvesting of the gardens supports physically-active lifestyles and connections with the land. Activities include walking the beaches, digging clams, moving rocks, building the rock wall, and aerating the soil (Deur et al., 2015). Socially, the gardens act as a forum for intergenerational sharing of cultural practices, language development, and socialization since elders and youth often worked together and built relationships at the clam gardens (Augustine & Dearden, 2014). At the community level, clam gardens are a source of food production, which strengthens food security and autonomy (Groesbeck et al., 2014). Community control over clam garden activities also supports sovereignty and self-determination, which have been identified as critical factors to improve Indigenous health, and support reconciliation (CSDH, 2007; TRC, 2015; Tsosie, 2007).

2.5.3. Impacts on Animal Health

Animal health is a state of physical and psychological well-being that supports productivity, reproduction, and physical and biological homeostasis (Gunnarsson, 2006). Animal health is often considered in association with animal welfare. The World Organization for Animal Health considers an animal to be in a good state of welfare when “it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from

unpleasant states such as pain, fear, and distress” (OIE, 2008). The health of animals that are harvested for human consumption are often considered at the population level. Population health can be evaluated using several indicators or combinations thereof including: the presence/absence of disease, growth and reproductive rates, density, and range. For the purpose of this paper, clam health will be considered a disease-free state that supports desirable growth rates and productivity and is safe for human consumption.

Clams are filter feeding, bivalve mollusks that feed primarily on phytoplankton in the water column by extending a siphon up through a hole in the sand. Larvae are free drifting before settling on sediment on the ocean floor to become sedentary adults that burrow in the intertidal zone of soft sediment beaches (Deur et al., 2015; DFO, 2013; Hanna, 2000). Survival and productivity of clams depends on “water temperature, salinity, currents, competition, predation, and the presence of toxins” (Hanna, 2000, p. 191).

There are many factors affecting clam health, either directly or indirectly by affecting water quality (Ringwood & Keppler, 2002). Toxins and sanitary contamination are important issues affecting clam health that result in public health concerns, since they represent the majority of causes resulting in area closures for shellfish harvesting (DFO, n.d.). These closures are the result of concerns over pathogens transmissible to humans such as *Escherichia coli* (*E. coli*), *Giardia lamblia*, *Cryptosporidium parvum*, *Salmonella typhi*, and *Vibrio sp.*, Hepatitis A, Norovirus, Paralytic Shellfish Poisoning (PSP), Amnesic Shellfish Poisoning (ASP), and Diarrhetic Shellfish Poisoning (DSP). These pathogens have variable impacts on clam growth and productivity and cause various symptoms in humans including combinations of gastrointestinal symptoms, headaches, fever, and occasionally death (BCCDC, 2014; Clayton, 2006).

Other factors affecting marine clam health include climate change and invasive species. Increased atmospheric carbon dioxide from climate change causes ocean acidification, which has been shown to negatively impact calcification, survival, growth and development of marine organisms (Kroeker et al., 2013). Overall impacts of invasive species on clams is unknown. Scientists speculate that the invasive European green crab, *Carcinus maenas* (Linnaeus), will negatively impact bivalve mollusk populations since mollusks are a preferred prey species. The impact on mollusks is suspected to be particularly intense in the Strait of Georgia, British Columbia, since it provides ideal conditions for green crab proliferation (Jamieson et al., 1998). Concurrently, experiments indicate that Dungeness crabs, *Cancer magister*, and red rock crabs, *Cancer productus*, prefer to prey upon the introduced varnish clam, *Nuttallia obscurata*, instead of littleneck clams. This preference may benefit littleneck clams by reducing the ability of the competing varnish clam to establish (Dudas et al., 2005).

Clam gardens act as a buffer to some of these threats by producing optimal conditions for clam growth, survival, and reproduction. Research indicates that the clam gardens create an environment where clam growth rates, density, biomass, and recruitment are superior to non-walled beaches (Deur et al., 2015; Groesbeck et al., 2014; Jackley et al., 2016). Table 2.1. provides details about the various ways clam gardens improve clam habitat.

Table 2.1. Ways clam gardens support optimal clam habitat	
Desirable factors provided by clam gardens	Methods and benefits of factor provision
Decreased beach slope	Beach slope is altered through wall construction that allows sediment accumulation on the landward side. The decreased slope increases the optimal tidal range for clam growth and survival (Groesbeck et al., 2014; Jackley et al., 2016).
Improved sediment quality	The sediment that accumulates on the landward side of the wall is mostly composed of coarse sand and shell hash. Indigenous people also intentionally add gravel and broken shells to the gardens to improve sediment quality. This coarse sand-gravel-shell hash sediment is ideal for clams, improving shell growth; preventing smothering; and increasing recruitment, larval settling cues and survival (Green et al., 2013; Groesbeck et al., 2014; Jackley et al., 2016; Lepofsky et al., 2015; Lepofsky & Caldwell, 2013; Thompson, 1995)
Provide space for smaller clams to grow	This space is created by removing rocks and other debris from the beach, and by selectively harvesting larger clams (Deur et al., 2015; Groesbeck et al., 2014; Lepofsky et al., 2015).
Sediment aeration	Sediment was actively aerated by Indigenous people who turned the sediment using a digging stick and rolled rocks to garden boundaries. Aeration improved clam growth and productivity by increasing access to oxygen (Deur et al., 2015; Groesbeck et al., 2014).
Water retention	The decreased beach slope allows more water retention and increased water temperature over clams. Increased water and water temperature improves larval recruitment and survival, triggers spawning, and enhances clam growth by expanding feeding time, and improving phytoplankton growth and delivery (Groesbeck et al., 2014; Jackley et al., 2016; Roegner, 2000; Shaw, 1986).

2.5.4. Impacts on Ecosystem Health

An ecosystem is a dynamic community of living organisms (ex. animals, plants, microbes) and environmental components (ex. water, air, sun) functioning together as a system (MEA, 2005). Humans and clams are part of the aquatic ecosystem of the Pacific Northwest, which provides for their needs and is shaped by their presence. Lu et al. (2014) built on the work of Rapport et al. (1998) to define ecosystem health as “the status and potential of an ecosystem to maintain its organizational structure, its vigor of function and resilience under stress, and to continuously provide quality ecosystem services for present and future generations in perpetuity”

(p. 3). Ecosystem services are the direct and indirect benefits ecosystems provide for humans. The Millennium Ecosystem Assessment (2005) lists four categories of services: “

Provisioning services such as food, water, timber, and fiber; *regulating services* that affect climate, floods, disease, waste, and water quality; *cultural services* that provide recreation, aesthetic, and spiritual benefits; and *supporting services* such as soil formation, photosynthesis, and nutrient cycling. (p. 5)

The health of BC’s coastal ecosystem faces many threats, many of which are shared with clams. General and key threats include overexploitation of organisms, habitat degradation, climate change, pollution, increased human presence and anthropogenic impacts, invasive species, and aquaculture (Halpern et al., 2008). Scientists suspect that climate change will affect harmful algal blooms (HABs), causing an increase in some geographical areas and a decrease in others. This change to phytoplankton communities is caused by increasing temperatures, changing currents, nutrient upwelling, surface stratification, and increased photosynthesis from carbon dioxide and micronutrients from more frequent land runoffs (Hallegraeff, 2010). An increase in HABs would make clams less safe to consume due to increased levels of toxins causing PSP, ASP, and DSP. For the clam gardens, rising sea levels associated with climate change may alter requirements for rock wall height and location, and/or limit access to beaches (Larsen et al., 2007; Lepofsky et al., 2015). Other environmental factors threatening the safety of shellfish for human consumption include pollutants. Sanitary pollutants represent a major and regular cause of area closures to shellfish harvesting, while other, less frequent pollutants, such as oil or chemical spills, also threaten environmental and public health (CFIA, 2019).

Coastal BC is particularly pressured by human activity since it is located in Canada’s most densely populated coastal area (Bouevitch, 2016). This intense human presence threatens the area with over-use, pollution, shoreline development, over-harvesting, and marine transport (Ayers et al., 2012; HTG et al., 2005). The logging industry also threatens ecosystem health. Log dumping, storage and transport can smother marine life, grounded logs damage habitat, and log booms create artificial shade (HTG et al., 2005). These factors have contributed to a decrease in intertidal resource abundance despite the highly productive nature of the habitat (HTG et al., 2005).

Clam gardens enhance ecosystem health by improving ecosystem organization, vigor, resilience, and by providing ecosystem services. Bivalves are considered keystone species since they influence nutrient levels and species composition around shellfish beds. As keystone species, bivalves can have both positive and negative impacts on other species and the ecosystem (Gallardi, 2014; Newell, 2004; Newell et al., 2002; Verwey, 1954).

Ecosystem organization is improved by clam gardens by enhancing and creating new habitat. Research indicates that the rock wall created new habitat that would not exist otherwise on soft-sediment beaches for desirable species like crabs, sea cucumbers, octopus, and several fish species (Lepofsky & Caldwell, 2013). Indigenous people would also harvest other aquatic and terrestrial species near the clam gardens that frequented to feed on clams or other species that were in greater abundance due to increased clam presence. For example, barnacles and sea

cucumbers were observed to be in greater abundance; predators such as raccoons, mink, and river otters scavenged the gardens at low tide; and sea ducks and geese occasionally foraged for clams, worms, and other invertebrates at the gardens (Deur et al., 2015). Furthermore, bivalves affect suspended particles and shell formation which can maintain, modify, or create new habitats (Gallardi, 2014). There is ongoing research working with traditional ecological knowledge and scientific experiments to further understand the impacts of clam gardens on local biodiversity.

Ecosystem vigor is enhanced by clam gardens since they improve conditions for not only clam growth and productivity, but for other species as well. Bivalves help moderate phytoplankton populations, biomass, and community composition by acting as grazers, depositing nitrogen and phosphorus in their biodeposits (feces and pseudofeces) which stimulate phytoplankton growth, and promoting nutrient (nitrogen, and phosphorus) cycling and removal (Gallardi, 2014; Lucas et al., 2016; Newell, 2004). Furthermore, shellfish beds act as habitat for several vertebrate and invertebrate species altering conditions to favour some species over others (e.g., deposit feeders) (Coen et al., 1999; Kaspar et al., 1985; Newell, 2004). Also, Augustine and Dearden (2014) determined that it is unlikely that clam gardens negatively impact the ecological integrity of the GINPR by examining six indicators of ecosystem integrity used by Parks Canada.

Evidence of how clam gardens improve ecosystem resilience is found when examining shellfish mariculture more generally. Filter-feeding performed by shellfish acts not only to feed the body, but can result in improved water quality in well flushed and oxygenated waters when water temperatures promote bivalve activity (Newell, 2004). When shellfish are grown in appropriate densities within their environment, filter-feeding reduces phytoplankton, organic matter, nutrients, viruses, and bacteria. The result is less turbidity, improved light transmission, and water that improves habitat for other biota including important plant species (Newell, 2004; Shumway et al., 2003). Bivalves also influence nutrient regeneration processes in sediment. Under aerobic conditions, bivalve biodeposits can participate in and encourage microbial-mediated, coupled nitrification-denitrification to permanently remove nitrogen from the system (Newell, 2004). By functioning to improve water quality, shellfish can help increase resilience when water quality is threatened by other factors (e.g., eutrophication). In addition, shell formation by bivalves captures carbon as calcium carbonate, which is sequestered in sediment following natural mortality acting as a buffer to ocean acidification and promoting long-term survival of their own species by supplementing sediment composition. Shells can also modify the seabed and create new habitat for other species. However, these positive benefits can be prevented if shells are continuously removed from the aquatic system (Gallardi, 2014; NRC, 2010). Furthermore, food particles filtered from the water column by shellfish, but not assimilated, become available for other sediment-dwelling organisms (Shumway et al., 2003). Providing access to food can potentially increase the resilience of other species and strengthen the overall ecosystem.

Clam gardens provide various ecosystem services. Provisioning services are provided because clams act as a source of food for humans and other animals. They also can make food

more available to other species through filter-feeding (Shumway et al., 2003). Regulating services are provided by clams helping to improve water quality through filter-feeding activities (Gallardi, 2014; Newell et al., 2002; Shumway et al., 2003). Cultural services are provided by clam gardens since they increase the availability and access to clams, which are very culturally significant to many Pacific Coast Indigenous peoples (Deur et al., 2015; Kuhnlein & Humphries, n.d.). Clam gardens also provide a forum for interactions with the land, intergenerational knowledge sharing, and cultural expression (Augustine & Dearden, 2014). Supporting services are provided since bivalves influence nutrient cycling (Gallardi, 2014; Newell, 2004).

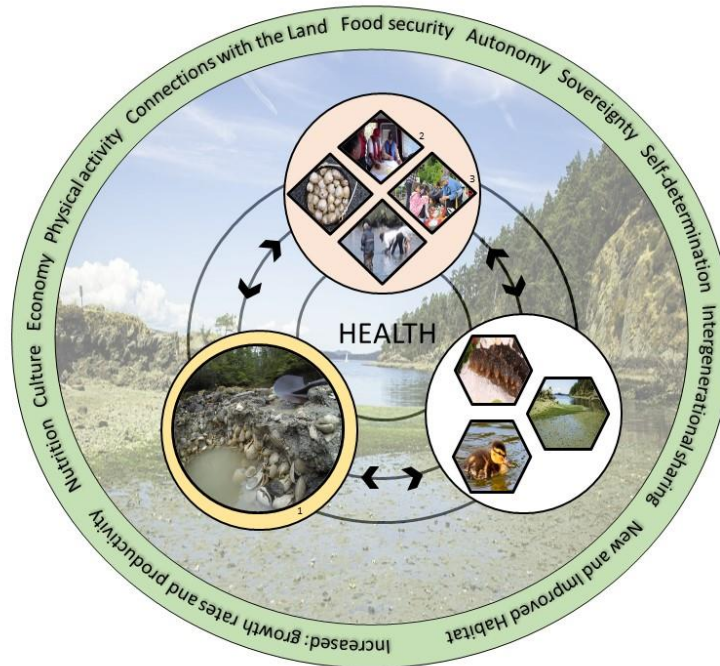


Figure 2.4. Beneficial human, animal, and ecosystem health connections in clam gardens

Photo credits: 1) Marco Hatch 2) Karen Fediuk 3) H. Wong

The literature on clam gardens does not indicate any specific negative consequences to human, animal, or ecosystem health. This is possibly a result of the limited amount and/or focus of current published research on clam gardens. One could speculate that health concerns may become more prevalent with increased interest in clam garden revitalization. These concerns may include: friction between and within different Indigenous communities, governmental bodies, and/or other fisheries over rights to garden management and decision-making; determining desirable clam densities and harvesting levels; decreasing water quality if clams exceed desirable densities; and potential harm to growth, reproduction, and/or survival of other species. For example, bivalves may alter desired food availability and quality for other species, and increase inter-species competition and/or out-compete other filter-feeders (Newell, 2004). Bivalves can decrease zooplankton and suspension feeder populations, which also has an effect on higher trophic levels (Gallardi, 2014). Furthermore, moderation of phytoplankton populations by bivalves has the potential to affect phytoplankton bloom intensity, which may either help

safeguard against or promote algal toxin-related diseases in humans (Gallardi, 2014). Moreover, in low water flow areas and/or when bivalves exceed desired densities, accumulation of biodeposits from bivalves may shift sediment microbial metabolism from aerobic to anaerobic resulting in anoxic conditions (Newell, 2004). Anoxic conditions can increase hydrogen sulfide, which can become toxic to benthic species, and prevent the denitrification process (Diaz & Rosenberg, 1995; Newell, 2004).

Table 2.2. Summary of potential positive and negative outcomes relating to health connections in clam gardens			
Factor	Potential Positive Outcomes	Potential Negative Outcomes	References
Clam gardens in general relating to human health	Promotes: <ul style="list-style-type: none"> Physical activity Land interactions Intergenerational sharing of culture and knowledge Food security Autonomy Self-determination Sovereignty 	Overtime success may cause friction between groups (i.e. different Indigenous individuals and communities, other harvesters, governmental bodies) about who manages clam gardens and how	(Augustine & Dearden, 2014; Deur et al., 2015; Groesbeck et al., 2014)
Clam garden construction and maintenance in general relating to animal health	Can optimize clam: <ul style="list-style-type: none"> Growth rates Biomass Density 		(Deur et al., 2015; Groesbeck et al., 2014; Jackley et al., 2016)
<ul style="list-style-type: none"> Rock wall construction 	<ul style="list-style-type: none"> Essential for clam garden existence Creates new and improved habitat that supports various species 	May exclude some species?	(Augustine & Dearden, 2014; CGN, n.d.; Deur et al., 2015; Groesbeck et al., 2014; Harper et al., 1995; Jackley et al., 2016; Lepofsky et al., 2015; Lepofsky & Caldwell, 2013; Moss & Wellman, 2017)
Increased water retention and temperature over clam gardens	Can promote clam: <ul style="list-style-type: none"> Larval recruitment and survival Spawning Enhanced growth by: <ul style="list-style-type: none"> Expanding feeding times 	May promote HABs	(Groesbeck et al., 2014; Hallegraeff, 2010; Jackley et al., 2016; Roegner, 2000; Shaw, 1986)

	<ul style="list-style-type: none"> ○ Improving phytoplankton growth 		
Clams moderate plankton populations	Stimulate phytoplankton growth <ul style="list-style-type: none"> • Provides food for clams and other species 	<ul style="list-style-type: none"> • Alter food availability and quality for some species • Decrease zooplankton and suspension feeder populations <ul style="list-style-type: none"> ○ Impacts on higher trophic levels • Increase inter-species competition • May promote HABs 	(Gallardi, 2014; Lucas et al., 2016; Newell, 2004)
Shellfish beds	Create habitat for some species	Discourage other species	(Coen et al., 1999; Kaspar et al., 1985; Newell, 2004)
Clam densities	When appropriate and located in well flushed and oxygenated water: <ul style="list-style-type: none"> • Improved water quality • Promote denitrification 	When inappropriate and in poorly flushed and low oxygenated water: <ul style="list-style-type: none"> • Create anoxic conditions <ul style="list-style-type: none"> ○ Toxic to benthic species ○ Prevents denitrification 	(Diaz & Rosenberg, 1995; Newell, 2004; Shumway et al., 2003)
Ocean acidification	Can be buffered through carbon capture by shell formation, if shells remain in the system		(Gallardi, 2014; NRC, 2010)

Concerns over public health safety regarding diseases in clams transmissible to humans are already well known and taken seriously for any shellfish harvesting in Canada (CFIA, 2016). The management of these diseases does impact clam gardens. For example, PSP is a health threat resulting from consumption of shellfish contaminated with toxic algae (DFO, 2015; Halstead & Schantz, 1984). PSP risk management in Canada includes monitoring biotoxin levels in select areas, and closing areas for harvest if saxitoxin levels are unknown or trend towards limits

considered unacceptable by the Canadian Food Inspection Agency (CFIA, 2019). Although area closures do not interfere with clam garden maintenance activities, closures do prevent harvest and consumption of shellfish, which are essential components of the clam garden experience for Indigenous people (Deur et al., 2015). Clam garden maintenance will support clam and ecosystem health to a degree; however, the inability to harvest clams will potentially decrease clam garden health over time by permitting unsustainable clam densities (Deur et al., 2015; Groesbeck et al., 2014; Jackley et al., 2016; Lepofsky et al., 2015; Lepofsky & Caldwell, 2013). The literature on clam gardens does not indicate if Indigenous communities would be in favour of harvesting clams without the opportunity for consumption. The example of PSP management also highlights an important consequence of the multitude of health connections in clam gardens. The interconnectivity between human, animal, and ecosystem health creates a vulnerability where a threat to coastal Indigenous people, clam, or coastal ecosystem health could nullify health benefits or decrease overall health in the other health domains. This does not mean that clam garden activity should be averted to avoid potential threats; instead, it means that understanding the interconnectivity between health domains in clam gardens is essential for creating risk management strategies supportive of holistic health. An investigation of whether the current risk management system for PSP supports clam garden health has not yet occurred.

2.6. CONCLUSION

Clam gardens are an exciting example of potential win-win ecological stewardship with deep human, animal, and ecosystem connections. These connections can promote concurrent health benefits in all health domains. Clams, being a core component of many Indigenous cultures, have important nutritional, cultural and economic benefits (Deur et al., 2015; Donatuto, 2008). The clam gardens improve individual and community health by providing a forum for reconnecting with the land and traditional knowledge, cultural expression, intergenerational knowledge sharing, and ecosystem rehabilitation. Clam gardens also improve community food security, autonomy and cohesion by providing a culturally appropriate food source dependent on community participation (Augustine & Dearden, 2014; Deur et al., 2015; Donatuto, 2008; Groesbeck et al., 2014). Construction, maintenance, and harvesting techniques in turn improve clam productivity, density, biomass, and recruitment (Deur et al., 2015; Groesbeck et al., 2014; Jackley et al., 2016). These activities also enhance ecosystem structure, function, and resilience by increasing biodiversity, creating new and improved habitat, and impacting nutrient cycling (Deur et al., 2015; Lepofsky & Caldwell, 2013). The multitude of potential health benefits and the interconnectivity between human, animal, and ecosystem health presents opportunities to simultaneously improve health in all domains, and further demonstrates the importance of clam garden revitalization projects. These interconnectivities also present challenges requiring risk management systems that appropriately consider the health connections in clam gardens.

Regarding the OH framework, my investigation adds to the emerging literature focusing on holistic approaches. This paper further demonstrates that OH is effective beyond cases involving infectious diseases and can be successfully applied to cases involving other aspects of health including food security, community participation, and social behaviors. Considering many Indigenous practices and Indigenous health involve an intricate connection with all else, including animals and the environment, my investigation may act as an example supporting the

benefits of OH for approaching cases involving traditional Indigenous practices and health (CSDH, 2007; Donatuto, 2008; King et al., 2009).

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3. ENVIRONMENTAL JUSTICE AND INDIGENOUS HEALTH: PARALYTIC SHELLFISH POISONING AND THE CANADIAN RISK MANAGEMENT SYSTEM

3.1. ABSTRACT

Shellfish harvesting is an important socioeconomic and cultural practice in many coastal communities, particularly for coastal Indigenous peoples. There are numerous barriers to shellfish harvesting facing Indigenous peoples and other harvesters. Contaminants from various sources represent a shared threat that can result in public health safety concerns. Considering the importance of public health safety *and* shellfish harvesting to coastal peoples, development of appropriate risk management systems is essential. Here, I focus on paralytic shellfish poisoning, a condition resulting from consumption of shellfish contaminated with algal toxins. I inquire whether the current Canadian risk management system for paralytic shellfish poisoning is environmentally just for Indigenous shellfish harvesters in British Columbia. Synthesizing the literature on risk and environmental justice, I offer a framework to evaluate whether risk management systems support environmentally just outcomes. I identify shortcomings in the existing approach and offer three key recommendations to improve the system: 1) increased meaningful collaborative participation with affected people in design, implementation, and re-evaluation of the system; 2) expanded and/or modified monitoring; and, 3) inclusion of Indigenous traditional knowledge alongside Western science to guide decision-making. This paper makes a significant contribution to ongoing attempts in environmental health and sustainability research to emphasize local agency, needs, values, and definitions of health and well-being.

KEYWORDS: Indigenous shellfish harvest, risk, environmental health, environmental justice, paralytic shellfish poisoning

3.2. INTRODUCTION

Shellfish are immensely important in coastal areas supporting the economy, lifestyle, culture, and health of many individuals, families, and communities (Evans et al., 2016; USEPA, 2018). In British Columbia (BC), shellfish and related industries provide numerous employment opportunities with a significant impact on local and national economies. In 2016, the Government of BC recorded the total shellfish harvest at 23,600 tonnes, landed value at CAD \$143 million, and wholesale value at CAD \$269 million. Species harvested, both wild and farmed, include: clam, crabs, geoducks, prawns, scallops, sea cucumbers, sea urchins, shrimp, mussels, and oysters (AgriServiceBC, 2016). The Government of BC recognizes the importance of shellfish and consequently has a strategic plan to capitalize on the potential for increased revenue and employment from the seafood industry. The strategy includes plans to develop the industry by supporting sustainable harvesting practices, promoting value added products, and increasing access to domestic, inter-provincial, and international markets (AgriServiceBC, 2015).

For Pacific Coast Indigenous communities, shellfish are a core component of local foodways and culture, in that they are central to people's diet and nutrition, food security, cultural traditions and interactions with the land (see chapter 2) (Deur et al., 2015; Donatuto,

2008; Harrison & Loring, 2016; Silver, 2014). Shellfish are also central to local commerce, where commercial clamming and traditional trading practices between First Nations represent important sources of income and trade in Indigenous communities (Deur et al., 2015; HTG, Evans et al., 2005). First Nations have practiced shellfish harvesting, management, and cultivation in various forms well before European contact, and have been very active in Federally-regulated commercial shellfish harvest (Groesbeck et al., 2014; Silver, 2014).

Clam gardens are a type of mariculture constructed by some Pacific Coast Indigenous peoples to improve shellfish production and harvest (Augustine & Dearden, 2014; Deur et al., 2015; Harper et al., 1995; Jackley, Gardner et al., 2016). They can provide a multitude of social, economic, and health benefits for these Indigenous communities, and clam gardening is increasingly recognized as an important example of community-directed ecological stewardship (see chapter 2) (Lepofsky et al., 2015). Though not commonly tended in recent years, there are several contemporary efforts to revitalize clam gardening (Augustine & Dearden, 2014; Deur et al., 2015; Neudorf et al., 2017). For example, in the Gulf Islands National Park Reserve (GINPR) in BC, the Hul'qumi'num Treaty Group (HTG), WSÁNEĆ First Nations, and Parks Canada are working collaboratively to restore two clam gardens with the goal to improve ecological enhancement for shellfish in the GINPR, and promote Indigenous cultural practices and food security (Bouevitch, 2016).

One significant barrier facing wild and cultivated shellfish harvesting activities is contamination. Possible contaminants include: sanitary contaminants (e.g. fecal coliforms), viruses (e.g. norovirus), algal toxins (e.g. saxitoxin, domoic acid, and okadaic acid), and chemicals (e.g. oil spills). These contaminants create a public health concern since consumption of contaminated shellfish can result in various, and sometimes debilitating symptoms (BCCDC, 2014; CFIA, 2019; Clayton, 2006). Considering both the potential severity of consuming contaminated shellfish and the importance of shellfish harvesting, the creation of appropriate risk management systems is essential to ensure simultaneous public safety and support for shellfish harvesting. Generally, risk describes the probability and severity of some future adverse event. Risk management is often conducted top-down by governments and safety experts, and there is a tendency for risk managers to favour simple restriction of risky behavior as a strategy for risk reduction (in this case, shellfish harvesting for consumption) instead of concurrently considering and promoting the benefits of risk taking (Adams, 1995). Risk management frameworks increasingly recognize the necessity of local participation in the definition and identification of risks as well as the development of appropriate risk management strategies (for example, Corburn, 2002; Kriebel et al., 2001; Loring & Duffy, 2011).

Environmental justice (EJ) is a concept that can be mobilized in a framework to consider the appropriateness of risk management strategies. EJ as a concept in science seeks to capture the extent to which exposure to risk and actions necessary to avoid, mitigate, and otherwise manage risks are shared equitably among different groups in society (Agyeman et al., 2002; Bullard, 1996, 2001; Bullard & Wright, 1993; Checker, 2007; Loring & Duffy, 2011; O'Neil, 2003; Schlosberg, 2004; Schlosberg & Carruthers, 2010). Generally, risk-related EJ is linked to whether people have an opportunity to participate in defining risk, policy creation, and

management. It also captures their level of risk exposure compared with others affected by the risk. Since society generally values reduction in risk over the potential benefits of risk taking, questions of EJ are often overlooked in the quest to reach the unattainable ‘zero risk’ (Adams, 1995; Beck, 1992).

As already noted, there are several different forms of shellfish contamination. Here, I focus on risks associated with paralytic shellfish poisoning (PSP) in coastal BC as an exemplar of risk management more generally. PSP is a serious human health concern, which can occur after consumption of shellfish contaminated with naturally occurring algal toxins (DFO, 2015; Halstead & Schantz, 1984). I do not question the importance of PSP risk management; rather, I seek to investigate whether the current risk management system supports outcomes that are environmentally just for Indigenous shellfish harvesters in BC. To do so, I first provide background information on risk and EJ and how these concepts may create tensions at the local and national level. Then, I apply an EJ framework to the existing PSP risk management system in Canada as it relates to Indigenous shellfish harvesting. I do so by analysing the Canadian Shellfish Sanitation Program manual of operations, and acquiring additional information from employees within the Canadian Food Inspection Agency, Environment and Climate Change Canada, the Department of Fisheries and Oceans Canada, and Parks Canada, a project partner, through e-mail and phone conversations between January and December 2018.

My analysis is conducted from an outsider perspective using available literature on the subject matter. It is important to acknowledge that perspectives on risk likely vary from researchers to federal government employees to local Indigenous peoples. Risk can be a highly contextual and cultural concept, in that different people may understand and define risk differently. As I elaborate below, there is a difficult balance in how risk is approached in policy, whereby too little attention to standardized metrics of risk can create environmental injustice, but likewise, hegemonic approaches to what is safe and unsafe, and what risks are worth taking, can also produce injustice (Loring & Duffy, 2011). The case of PSP presented here offers insights for pursuing an interplay of state- and place-based approaches to defining, monitoring, and making decisions about risks through a participatory and collaborative process.

3.3. BACKGROUND

3.3.1. Risk

Adams (1995) describes risk as “the perception of the probability and magnitude of some future adverse event” (p.180). *Perception*, here, stresses the subjectivity involved in risk, which is often missed in attempts by scientists and policymakers to objectively measure risk using statistical approaches (Adams, 1995). Perception is strongly rooted in worldview, and is shaped by local culture and social experiences, making risk a place-based phenomenon (Adams, 1995; Checker, 2007; Donatuto, 2008; Loring & Duffy, 2011). Risk is intricately connected with health, and, like health, the perception of risk used most commonly in risk management tends to only focus on physiological impacts (e.g. injury, death, and disease) (Boorse, 1977; Donatuto, 2008; House, 2017; King et al., 2009; Loring & Gerlach, 2009). However, risk and health are both multifaceted, and like risk, the perception of health is dependent on culture and social experiences (Arquette et al., 2002). The World Health Organization defines health as “a state of

complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 1946). Many Indigenous cultures expand this definition by understanding humans to be intricately connected and part of all else through a physical, emotional, intellectual, and spiritual connection. For many, health also involves knowledge transmission and practice of traditional teachings, culture, and language; community cohesion; and food security (Arquette et al., 2002; CSDH, 2007; Donatuto, 2008; King et al., 2009). Within a holistic vision of health, risk cannot be solely understood through physiological impacts since it can have positive and negative impacts on multiple aspects of health (Arquette et al., 2002; Donatuto, 2008; Engel, 1977; Loring & Gerlach, 2009).

In general, risks are a necessary part of life and one cannot/should not avoid all risks. Determining whether a risk is worth taking depends on “balance behaviour” where individuals or groups weight the perceived benefits and dangers of taking said risk, and characterize and prioritize threats (Adams, 1995; Donatuto, 2008). Individuals and groups use intellect and emotion to assess risk, which is influenced by economics, gender, culture, social factors, power, and race (Davidson & Freudenburg, 1996; Drake, 1992; Flynn et al., 1994; Johnson, 1991; Norgaard, 2007). In general, people are less willing to take risks that are involuntary, unfair, industrial in scale, and/or cause a significant emotional response (Adams, 1995; Byrd et al., 1990; Sandman, 1989; Slovic et al., 1979). The perception of benefits and voluntariness often depends on whether the risk comes from inside one’s own culture (higher benefits, more voluntary), or from an outside source (lower benefits, less voluntary). Furthermore, the larger the outside agency imposing the risk, the less voluntary it appears to those taking the risk (Adams, 1995).

Although risks have always existed, they have become a primary focus of society with the rise of science and technology (Beck, 1992; Giddens, 1999). Giddens (1999) argues this change in focus occurred when humans shifted their concern from what nature could do to them to what they are doing to nature, and when humans no longer lived based on the understanding that their lives were solely controlled by the whims of gods. The idea that risks are influenced by decision-making produced the concept of accountability associated with risk, and a focus on influencing the future. With the advancement of statistics, risks were considered predictable, which resulted in the creation of insurance and compensation for risks. Risks that were once considered an individual concern became a systematic problem needing political regulation, thus a need for risk management (Beck, 1992; Giddens, 1999).

Risk management in today’s society is often based on the concept of risk prevention and the perception that people want to navigate towards a state of zero risk (Adams, 1995; Beck, 1992). Another assumption is that no exposure means no adverse health effects. However, these assumptions ignore different worldviews and perceptions of risk, and benefits that occur from risk taking. For example, serious health effects can occur when traditional cultural practices are halted in attempts to protect against toxic substance exposure (Arquette et al., 2002; Loring & Duffy, 2011). An increase in scientific knowledge is considered by most risk managers as the best way to resolve uncertainty in risk decision-making (Adams, 1995).

Western science has been considered the ultimate knowledge system to understand risk and guide risk management, particularly in environmental issues, where it is valued higher than any other knowledge system (Beck, 1992; Checker, 2007; Giddens, 1999; Raibmon, 2018). Scientific communication is generally considered unidirectional, where information is passed from scientists to society without participatory discussions (Checker, 2007). However, science is an imperfect system, rooted in assumptions, and under constant revision and uncertainty (Adams, 1995; Beck, 1992; Checker, 2007; Giddens, 1999). For this reason, some scholars question the validity of science as a knowledge system to uphold EJ (Brulle & Pellow, 2006; Checker, 2007). Brulle and Pellow (2006) summarize the views of many EJ activists by describing traditional “objective” science as “a systematically disempowering discipline and practice rooted in Western Enlightenment concepts that tend to separate human beings and cultures from nature in a way that ignores the importance of non-European peoples’ contributions to knowledge and environmental sustainability” (p.115). What type and how science is conducted is very subjective and dependent on power relations, economics, politics, and culture (Brulle & Pellow, 2006; Checker, 2007). Capitalism drives scientific and technological advancement in the quest for endless production and consumption. This system creates complicated risks and stresses ecological systems, with the effects disproportionately distributed to disadvantaged demographic groups (Beck, 1992; Brulle & Pellow, 2006a). Considering the limitations of science, developing a better understanding of beliefs and inference about risk is just as, or possibly more important than an increase in scientific evidence (Adams, 1995). Other sources of knowledge, such as traditional knowledge, are important for understanding different ‘balance behaviours’ and inference associated with risk, and should play an equitable role in decision-making (Arquette et al., 2002; Donatuto, 2008). Arquette et al. (2002) believe consideration of Indigenous knowledge is beneficial and intricately tied to Indigenous rights. The authors comment that, “the traditional, cultural, ecologic, and scientific knowledge of Native people is a tremendous asset to all decision makers. When they are not respectfully included at the decision-making table, sovereignty and treaty rights are often violated” (p.260).

Following the theme of risk prevention, risk management has focused on safety, where decisions are increasingly put in the hands of governments and ‘safety experts’ to reduce risk for the greater good (Adams, 1995). Governments tend to use a top-down approach to risk management for policies and enforcement that they believe reduce risk, since they generally perceive threats to be greater than acceptable levels of risk (Adams, 1995). The increased power of the state in risk management has been justified by the argument that risks associated with the complex nature of technology are beyond comprehension and self-regulation by individuals. Increased state power has also developed along with, or as a result of, an increased tendency of society and the justice system to want someone to take the burden of responsibility for every accident (Adams, 1995). The fear of social and legal ramifications along with uncertainty has led governments and experts to favour precautionary themed risk management based on the most sensitive demographic subgroups (Giddens, 1999; Loring & Duffy, 2011; PCO, 2003).

The precautionary principle, one popular framework for acting on risk within the EJ movement, has four main components: “taking preventive action in the face of uncertainty; shifting the burden of proof to the proponents of an activity; exploring a wide range of

alternatives to possibly harmful actions; and increasing public participation in decision making” (Brulle & Pellow, 2006; Kriebel et al., 2001, p.871). The government of Canada has a history of applying precaution in federal jurisdictions and as a party to several international agreements. It has a framework for precautionary risk management that guides science-based decision-making in areas of health, safety, the environment, and natural resources. The framework states that a precautionary approach should be used when decisions are required regarding risks with potential serious or irreparable harm in the face of scientific uncertainty (PCO, 2003). National-level precautionary risk management is beneficial in its ability to develop national standards and in some cases, to help safeguard against big business. However, top-down national-level risk management as a sole managing body can be restricted in its ability to accurately assess risk at the local level when local participation is limited (Loring & Duffy, 2011). Risk management that excludes collaboration with local people has been criticized for perpetrating environmental injustice by ignoring local opinions and knowledge (Corburn, 2002). Furthermore, placing risk management in government hands allows the politicization of risk where power can dictate risk instead of social priorities and values (Donatuto, 2008; Irwin, 1985). Also, state-led precautionary risk management may overstate risk, which can result in avoidance behaviours that reduce exposure to the benefits of risk taking (Arquette et al., 2002; Donatuto, 2008; Loring & Duffy, 2011; Loring et al., 2010; Trainor et al., 2009).

Considering the benefits and limitations of state-level risk management, Loring and Duffy (2011) argue that a combination of state-level and place-based approaches to risk management produce results that more accurately protect the health and wills of the people. The authors described three main contributions of place-based approaches to risk management: first, improved ability to properly characterize risks and their relationship to health outcomes; second, greater acceptance and compliance with risk avoidance strategies; and third, greater transparency in the risk management process, which increases EJ (Loring & Duffy, 2011). Although the Government of Canada does not specifically promote collaborative, place-based approaches to risk management, their framework for precautionary risk management recommends actions that could be achieved by a place-based approach. On several occasions, the framework stresses the need for meaningful public participation to: recognize “ambiguities and uncertainties, and promote acceptance of different perspectives” (p.10), solve problems and resolve conflicts, understand tolerance for risks and management measures, understand an acceptable level of protection by society, and consider broad costs and benefits of decisions so net benefits are received by the public. The framework also states that “public involvement should be structured into the scientific review and advisory process, as well as the decision-making process” (p.10), but that this involvement depends on context and timelines for decisions. Moreover, the framework recommends that precautionary measures should be implemented temporarily with follow-up activities that include research and monitoring to support re-evaluation of decisions. The framework also advises that decisions be made by considering scientific advice from various sources, including Indigenous traditional knowledge, and encourages a high level of transparency and accountability (PCO, 2003).

3.3.2. Environmental Justice

The linkages between human and environmental health have long been appreciated in the worldviews and practices of many cultures (Durkalec et al., 2015; Loring & Gerlach, 2009; Richmond & Ross, 2009). This connection results in a trend where social and environmental outcomes course together either towards wellness and sustainability or ill-health and degradation (Loring et al., 2016). It has also become increasingly apparent that environmental quality is intricately connected to human equality and societal organization (Agyeman, 1990; Beck, 1992; Brulle & Pellow, 2006). Cases of environmental degradation are almost always connected to equality, rights, social justice, and/or quality of life (Agyeman et al., 2002). Bullard (1996) defines EJ as “the principle that all people and communities are entitled to equal protection of environmental and public health laws and regulations” (p.493). The EJ movement largely began to rectify the unfair practices of industry and governments that resulted in the unequal distribution of environmental risks and risk avoidance behaviour to disadvantaged demographic groups (Agyeman et al., 2002; Bullard, 1996, 2001; Bullard & Wright, 1993; Checker, 2007; Loring & Duffy, 2011; O’Neil, 2003; Schlosberg, 2004; Schlosberg & Carruthers, 2010). There is extensive research that shows how placement and regulation of unwanted land use sites discriminates against poor and racial minority communities including Indigenous communities (Agyeman et al., 2002; Bullard, 1996, 2001; Bullard & Wright, 1993; Wiebe, 2016).

Although risk distribution is an essential component of EJ, Schlosberg (2004) argues other essential and interrelated components of EJ are *recognition* of diversity in people and experiences, and *participation* in environmental policy creation and management. Although Schlosberg (2004) recognizes that other scholars have appreciated recognition and participation within the context of distribution, he believes they deserve a greater focus. People who are not recognized, do not participate, and whose views are not respected and valued, are not considered in environmental policy. Ways of life and cultures of many people are in peril because they are devalued, ignored, and disrespected by those in power, and the disenfranchised are not provided a say in decisions affecting their survival. The disempowerment of minorities is a central precursor to inequity of risk distribution. Power struggles and the threat of this lack of recognition emphasizes the need for participatory and inclusive democratic processes (Schlosberg, 2004; Shiva, 2000). According to Schlosberg (2004), EJ is achieved when distribution, recognition, and participation are addressed simultaneously.

The capabilities approach to EJ described by Schlosberg and Carruthers (2010), builds on distribution, recognition, and participation, referred to as capabilities by the authors, to understand that EJ for some is a broader, more pluralistic, and integrated concept. The capabilities approach takes the stance, like holistic health, that EJ is more than a baseline, it supports capacity for people and communities to flourish in the lives they choose for themselves. This concept is supported and built on by Agyeman et al. (2002) who recognized the connection between EJ and sustainability. They define sustainability as a focus “to ensure a better life for all, in a just and equitable manner, whilst living within the limits of supporting ecosystems” (p. 78). Following this definition, the authors agree that EJ should support better lives for people, but add to Schlosberg and Carruthers (2010) by understanding this support is only just when it respects the limits of ecosystems (Agyeman et al., 2002). The capabilities approach is successful because

it incorporates a range of concerns and can simultaneously address interrelated issues, such as equity, democratic rights, cultural differences, and participation. Like place-based approaches to risk management, the capabilities approach believes local participation in defining and approaching EJ is essential to success. The capabilities approach by Schlosberg and Carruthers (2010) is different from other theoretical literature on capabilities in that it appreciates the community level factor of EJ. They argue that some environmental injustices are better addressed at the community, rather than the individual level because of the nature of the injustice and the organization of those affected. The authors emphasize that the capabilities approach is a method to understand the multifaceted nature of Indigenous EJ (Schlosberg & Carruthers, 2010).

Indigenous EJ is diverse, community focused, and has some unique characteristics. Unlike other racial minorities, Tsosie (2007) argues that EJ for Indigenous peoples goes beyond civil rights to include the right of self-government. Therefore, injustice also lies in governments failing to recognize Indigenous sovereignty and right to determine environmental outcomes in their territories (Tsosie, 2007). However, since many environmental issues cross intergovernmental borders, recognizing sovereignty is not enough to ensure Indigenous EJ. EJ also includes recognition of “the interrelated cultural, spiritual, social, ecological, economic, and political dimensions of environmental issues”, and the connection Indigenous people have with the land (O’Neil, 2003, p.2; Tsosie, 2007). Therefore, EJ must include Indigenous self-determination to protect traditional ways on traditional territories regardless of acknowledged sovereignty over said lands (Tsosie, 2007). These other capabilities exist for Indigenous people because of their special status as first peoples, and because EJ for them can move beyond equality to a fight for existence, since environmental injustice can threaten community and cultural survival (Schlosberg & Carruthers, 2010; Tsosie, 2007). In Canada, the Truth and Reconciliation Commission (TRC) makes several recommendations related to Indigenous EJ including a recognition of Indigenous rights to: their lands, self-determination and autonomy, practice and development of culture, and participation in decision-making affecting their affairs (TRC, 2015a; UN, 2008).

3.3.3. Paralytic Shellfish Poisoning (PSP)

Paralytic shellfish poisoning is a health threat, mostly to humans, but also to shellfish and other species. It occurs when filter-feeding bivalve shellfish contaminated with toxin-containing algae are consumed. The toxin(s) can be one or more of a group of naturally occurring algal toxins that accumulate in shellfish through filter-feeding of toxic dinoflagellates (“Dinoflagellates,” 2003; Halstead & Schantz, 1984; Wekell et al., 2004). The most toxic of the PSP toxins is saxitoxin, with at least 16 variants currently identified (Wekell et al., 2004). Saxitoxin is a neurotoxin that harms nervous tissue by binding to and inhibiting sodium channels in excitable nerve cell membranes, effectively blocking nerve impulses (DFO, 2015; Halstead & Schantz, 1984). Toxins can bioconcentrate in the flesh of some filter feeding shellfish causing variable health impacts, and producing toxicity when consumed by mammals, birds and fish (Al-Ghelani et al., 2005; Halstead & Schantz, 1984; Moore et al., 2008). In humans, resulting nerve damage can cause symptoms within five to 30 minutes usually involving tingling, burning, and numbness in the mouth and face that gradually spreads to other areas of the body, particularly the hands and feet. Paralysis can occur in more severe cases resulting in impaired motor

coordination and speech, and in extreme cases, suppression of muscles required for respiration leading to respiratory arrest and death (DFO, 2015; Halstead & Schantz, 1984). There is no known antidote, and the toxins are not denatured by normal cooking or freezing techniques (BCCDC, n.d.; DFO, 2015; Gessner & Middaugh, 1995; Halstead & Schantz, 1984). There have been no reported human cases of PSP in BC within the last ten years (BCCDC, n.d.).

Toxin accumulation in shellfish is more common during population surges of algae, called harmful algal blooms (HABs), which generally occur sporadically and unpredictably between May and October along the Pacific Coast (Halstead & Schantz, 1984). Shellfish eventually clear the toxin from their bodies becoming once again safe for consumption; however, rates of toxin accumulation and elimination vary between species. For example, butter clams can accumulate toxin in the siphon, neck and gills for up to a year (BCCDA, n.d.; CFIA, 2019; Halstead & Schantz, 1984; n.d.). Evidence suggests that there is a global increase in HABs, which is attributed to climate change and abnormal weather conditions, eutrophication, transport of algae in ballast water, and increased awareness (Al-Ghelani et al., 2005; Dolah, 2000; Moore et al., 2008). Exact environmental conditions required to produce a bloom are unknown; however, there are several natural and anthropogenic environmental factors that increase the potential for HABs (Al-Ghelani et al., 2005; Halstead & Schantz, 1984). Photosynthesis and plankton growth increase with rising water temperature, creating a greater opportunity for algal blooms to occur and become toxic. Changes in water movement, such as currents, nutrient upwelling and surface stratification can also provide the environmental conditions to stimulate HABs (Al-Ghelani et al., 2005; Hallegraeff, 2010; Halstead & Schantz, 1984; Moore et al., 2008). Furthermore, there is some evidence that eutrophication from anthropogenic origins, such as land runoff from agricultural areas, can trigger a bloom (Al-Ghelani et al., 2005).

3.3.4. PSP Risk Management: The Canadian Shellfish Sanitation Program

Considering the unpredictable nature of HABs and the potential harms to human health, including death, the current, most reliable preventative measure for PSP is considered to be monitoring toxin levels in shellfish and appropriately closing areas to shellfish harvesting (Halstead & Schantz, 1984). In Canada, the Canadian Shellfish Sanitation Program (CSSP) is a federal food safety program tasked to protect Canadians from the “health risks associated with the consumption of contaminated bivalve molluscan shellfish” (CFIA, 2016). The CSSP is managed in collaboration between three federal agencies: the Canadian Food Inspection Agency (CFIA), Environment and Climate Change Canada (ECCC), and the Department of Fisheries and Oceans Canada (DFO), with additional support provided by Health Canada when required. The CSSP has legal authority under the Fisheries Act, the Management of Contaminated Fisheries Regulations, the Safe Food for Canadians Act and Regulations, and the Pacific Aquaculture Regulations. The Acts and Regulations provide the CFIA, ECCC, and DFO with the responsibility to control harvesting and sale of shellfish and assess harvesting waters for sanitation by measuring bacteriological quality and pollution sources (CFIA, 2019). CFIA is the lead agency involved and responsible for the marine biotoxins control program and any microbiological monitoring not performed by ECCC, ECCC is responsible for monitoring bacteriological water quality and identifying and evaluating sanitary pollution sources, and DFO enacts and enforces area status and classification (CFIA, 2019). The CSSP manual is considered

a national document that does not detail all region-specific aspects of the program (ECCC employee, personal communication, December 6, 2018).

Under the CSSP, coastal harvest areas are classified as approved, conditionally approved, restricted, conditionally restricted, or prohibited based on assessments of shellfish and/or water for biotoxins, microbials, and other chemicals. The decision to classify/declassify an area is made by the Regional Interdepartmental Shellfish Committee (RISC) based on information presented by CFIA and ECCC. The committee consists of regional representatives from the three participating federal agencies. An area declassification occurs, for example, when harvesting levels no longer justify monitoring. A declassified area is not monitored under the CSSP and the CSSP manual recommends that shellfish should not be harvested from an unclassified area. An approved classification is achieved if the area is “not contaminated with pathogenic micro-organisms to the extent that consuming the shellfish might be hazardous” (CFIA, 2019, section 4.1.3.1.). Water in approved locations must have: all actual and potential sources of pollution and other harmful substances identified and determined not to impact the area; a median fecal coliform most probable number (MPN) of $\leq 14/100$ mL with no more than 10% of samples exceeding 43/100 mL for a five-tube decimal dilution test; or the geometric mean fecal coliform MPN must be $\leq 14/100$ mL with $\leq 43/100$ mL for the estimated 90th percentile of fecal coliform MPN in a five-tube decimal dilution test (CFIA, 2019). Conditionally approved areas meet the approval criteria, but have a specific and predictable period when the area is subjected to factors preventing approval, for example seasonal human/animal activity, or discharge from wastewater systems. Restricted areas exceed criteria for approved classification; thus, shellfish harvesting is prohibited except with special license, for example for depuration. Conditionally restricted areas meet the restricted criteria for a specific period, with the manual being unclear about what occurs in the remaining time. Prohibited areas have conditions less favorable than restricted areas where shellfish harvest is not permitted except with special license to harvest seed, spat, bait, and for some scientific purposes (CFIA, 2019).

Area status (i.e. open or closed) is different from area classification. An open area is deemed acceptable for shellfish harvest, whereas a closed area is ineligible for harvesting except under specific conditions. Areas classified as approved, conditionally approved, conditionally restricted, or restricted all can have an open status depending on specific criteria. Similarly, any type of area classification can be closed under conditions threatening public health, for example, microbiological or biotoxin levels exceed CSSP standards, seasonal change in water quality, heavy rainfall events, or contaminants spill. Area status is based on several surveys aimed at assessing overall shellfish health for human consumption. ECCC’s shellfish water classification program is responsible for identifying and evaluating sources of sanitary pollution in shellfish harvest waters (CFIA, 2019). Sanitary pollutants are usually microbials, such as *Escherichia coli* (*E. coli*), *Salmonella typhi*, and *Vibrio sp.*, which can cause various health issues in humans including potentially severe gastrointestinal symptoms (BCCDC, 2014; Clayton, 2006). In general, microbials are evaluated by measuring fecal coliforms (see above for acceptable levels) as an indicator for overall bacteriological contamination (ECCC employee, personal communication, December 6, 2018).

The CFIA's marine biotoxins control program monitors levels of biotoxins; specifically saxitoxin, domoic acid, and okadaic acid, dinophysis toxin, and pectenotoxin, to reduce the occurrence of PSP, amnesic shellfish poison (ASP), and diarrhetic shellfish poison (DSP) respectively. Sampling sites are chosen based on: proximity to, and amount of shellfish in the area, year-round accessibility, and history of toxicity in the area. Closure of a harvesting area occurs when saxitoxin levels are $\geq 80 \mu\text{g}/100 \text{ g}$, domoic acid levels are $\geq 20 \mu\text{g}/\text{g}$, or okadaic acid, dinophysis toxin, and pectenotoxin levels are $\geq 0.2 \mu\text{g}/\text{g}$, when sampling and historical information suggest contamination will exceed these values, or when a suspected or confirmed biotoxin related illness occurs in the area (CFIA, 2012). These values are also used by many international trading partners (FAO, n.d.). A closed area will only reopen when three consecutive samples provide acceptable values within a minimum of a 14-day period and when sampling in adjacent areas supports a reopening. Harvesting areas may also be closed until an investigation can occur in an area suspected of biotoxin contamination (CFIA, 2019). All laboratories evaluating CSSP samples are required to be accredited by a recognized Canadian body to the "international standard ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories" (CFIA, 2019, section 7.1). In addition, the CFIA does approve the removal of clam siphons as a method to help mitigate exposure to biotoxins and provides customized testing for siphonless shellfish. This technique has been successfully applied in several northern Indigenous communities (ECCC employee, personal communication, December 6, 2018).

In Fulford Harbour (DFO Management Subarea 18-10), where the GINPR clam garden project is conducted, ECCC has four sampling sites where water fecal coliforms and salinity are monitored five times per year (ECCC employee, personal communication, February 15, 2018). However, these sites do not include the areas where the two clam gardens are located; as such, the clam gardens remain unclassified although initial consultation has occurred to classify the area (ECCC, personal communication, December 6, 2018). The CFIA does not have monitoring stations for biotoxins in that area, which means risk management is determined through monitoring stations in adjacent subareas (CFIA employee, personal communication, January 31, 2018). In the absence of a monitoring station, Subarea 18-10 remains permanently closed unless an opening is requested (CFIA employee, personal communication, March 16, 2018). This is a common practice in DFO Management Areas lacking monitoring sites; however, it is not mentioned in the CSSP manual (DFO, n.d.; Parks Canada employee, personal communication, November 30, 2018). Of the 23 subareas surrounding Fulford Harbour, BC (18-10), only four (18-3, 18-8, 19-5 and 19-8) are regularly sampled for biotoxins (see figure 3.1.). To open an unmonitored area, a request for an opening has to be made to the CFIA a few weeks before the desired opening date. CFIA will then evaluate levels in adjacent areas that have monitoring sites. A sample of the target species for the harvest must also be collected following protocols in a CFIA manual and shipped to an approved laboratory. A combination of test results and adjacent area evaluation are used to determine if an opening is granted (Parks Canada employee, personal communication, November 30, 2018).

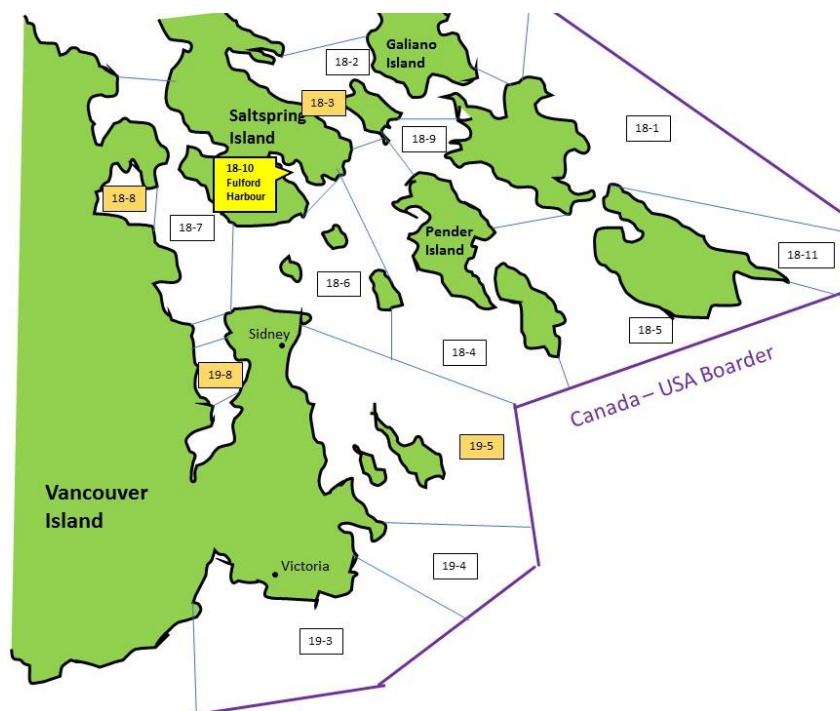


Figure 3.1. DFO Management Areas maps in the Pacific region for areas 18 and 19 with emphasis on areas monitored for biotoxins in relation to Fulford Harbour (DFO, n.d.)

3.4. METHODS

To assess whether the above systems of risk management for PSP support EJ for Indigenous shellfish harvesters, I used a framework based on key factors from the literature on risk and EJ (Table 3.1). The table provides a hypothetical example of how each factor could be implemented in PSP risk management to support EJ for Indigenous shellfish harvesters.

Table 3.1. Framework to evaluate whether risk management systems support Indigenous environmental justice			
Theme	Does the risk management system...	References	Hypothetical example in the context of Indigenous shellfish harvesting and PSP
<i>Defining and assessing risk</i>	Include and consider local Indigenous culture, experiences, spirituality, and economics in the context of the colonial legacy?	(Adams, 1995; Arquette et al., 2002; Checker, 2007; Donatuto, 2008; Loring & Duffy, 2011; O’Neil, 2003; Schlosberg, 2004)	Indigenous communities involved in shellfish harvesting are consulted to understand their traditional and current relationships with shellfish harvesting, and how these relationships are impacted by PSP.
	Consider benefits and dangers perceived by the affected people?	(Adams, 1995; Arquette et al., 2002; Donatuto,	Indigenous communities involved in shellfish harvesting are consulted to determine what they consider to be the benefits

		2008; Loring & Duffy, 2011)	of shellfish harvest and consumption, the dangers associated with PSP, where they believe the balance between benefits and dangers should exist, and what is an acceptable level of risk.
	Have equitable distribution of risk and risk avoidance behaviour?	(Agyeman et al., 2002; Bullard, 1996, 2001; Bullard & Wright, 1993; Loring & Duffy, 2011; Schlosberg, 2004)	Indigenous shellfish harvesting locations have an equal threat-level of PSP compared to shellfish harvesting areas for non-Indigenous peoples. Indigenous communities involved in shellfish harvesting are required to have an equal level of risk avoidance behaviour from PSP and the risk management system as other shellfish harvesting groups.
<i>Participation</i>	Include both state-led and place-based approaches to management?	(Loring & Duffy, 2011)	The Canadian Government and Indigenous communities involved in shellfish harvesting are collaboratively involved in PSP risk management.
	Include meaningful participation and collaboration with the affected people in defining, assessing, and managing risk?	(Arquette et al., 2002; Corburn, 2002; Donatuto, 2008; Loring & Duffy, 2011; PCO, 2003; Schlosberg, 2004; Schlosberg & Carruthers, 2010)	The Government of Canada collaboratively participates with Indigenous communities involved in shellfish harvesting to define, assess, and manage PSP risk. Indigenous perspectives are included in risk management systems.
<i>Characteristics</i>	Support the affected people to flourish in the lives they choose for themselves, within ecosystem limits?	(Agyeman et al., 2002; Schlosberg & Carruthers, 2010)	The PSP risk management system protects against PSP, while supporting development and long-term success of Indigenous shellfish harvesting.
	Support Indigenous capabilities for environmental justice (i.e. sovereignty, self-determination, and	(Schlosberg & Carruthers, 2010; Tsosie, 2007)	The PSP risk management system works within the sovereignty of First Nations and respects and includes Indigenous government's decisions related to their traditional territories. The cultures, traditions, and

	connections with the land)?		ways of life of Indigenous communities involved in shellfish harvesting are respected, considered, and supported in PSP risk management
	Provide a process for re-evaluating decisions that includes follow-up research and monitoring in collaboration with the Indigenous communities?	(PCO, 2003; Schlosberg, 2004)	The PSP risk management system is periodically re-evaluated in collaboration with Indigenous communities involved in shellfish harvesting with the goal to maximize protection against PSP, while supporting Indigenous shellfish harvesting. Indigenous communities participate in the research and monitoring that supports the PSP risk management system.
<i>Knowledge influencing decision-making</i>	Consider traditional Indigenous knowledge along with Western scientific knowledge for decision-making?	(Adams, 1995; Arquette et al., 2002; Donatuto, 2008; Ford et al., 2016; PCO, 2003; Schlosberg, 2004; Stefanelli et al., 2017)	Indigenous knowledge from Indigenous communities involved in shellfish harvesting is considered along with Western scientific knowledge in the design, implementation, and re-evaluation of the PSP risk management system.

3.5. FRAMEWORK APPLICATION

In the case of PSP risk management for Indigenous shellfish harvesters, the risk to be taken is shellfish harvesting with intent to consume. Shellfish consumption could result in contamination and illness from PSP-toxins, the threat.

3.5.1. Defining and assessing risk

Does the approach include and consider local Indigenous culture, experiences, spirituality, and economics in the context of the colonial legacy?

There is no indication from the CSSP manual that Indigenous culture, experience, spirituality, and economics were considered in the design and implementation of the program (CFIA, 2019). Regarding biotoxins, the manual suggests that the CSSP was designed and focuses only around preventing exposure to higher than acceptable levels for humans (CFIA, 2019). There are some regional specific additions to the manual that try to facilitate the accommodation of Indigenous culture, experiences, spirituality, and economics. For example, the permitted removal of shellfish siphons to help mitigate exposure to biotoxins is a made-in-BC solution

separate from the CSSP manual that was established to try to facilitate shellfish harvest and consumption practices, particularly in northern Indigenous communities (ECCC employee, personal communication, December 6, 2018).

Does the approach consider benefits and dangers perceived by the affected people?

The CSSP focuses on the negative consequences of shellfish consumption, which are illness and potential death associated with PSP-toxins, where there is no known antidote (Gessner & Middaugh, 1995; Halstead & Schantz, 1984; DFO, 2015; BCCDC, n.d.). This focus is evident from their goal, to protect Canadians from the “health risks associated with the consumption of contaminated bivalve molluscan shellfish”(CFIA, 2012, 2016), and from their use of the precautionary principle. The CSSP enacts the precautionary principle by focusing on contamination prevention by closing harvesting areas when biotoxins are above, or may go above CFIA determined acceptable limits, or when scientific information on biotoxin levels is lacking (CFIA, 2012;). For example, because of the absence of biotoxin monitoring in the area where the GINPR clam garden project is located (DFO Subarea 18-10), the area remains closed to shellfish harvesting to reduce chances of human contamination (CFIA employee, personal communication, January 31, 2018).

The method of precautionary risk management outlined in the CSSP manual does not incorporate other aspects of the precautionary principle including exploring alternative actions and collaborating with the Indigenous communities in decision-making (CFIA, 2012; Kriebel et al., 2001; PCO, 2003). The CSSP manual of operations makes no reference to collaborating with local people in risk management and decision-making processes; however, Indigenous stakeholders can attend and raise concerns at Pacific Regional Interdepartmental Shellfish Committee (PRISC) meetings (see section 3.5.2. for details) (CFIA, 2019; ECCC employee, personal communication, December 6, 2018). Input from Indigenous peoples is required for CSSP members to understand and consider the various benefits of shellfish harvesting and consumption instead of only focusing on negative consequences.

In the previous chapter, I described the vast and multifaceted health connections between Indigenous people, clams, and the ecosystem in clam garden projects. Clams have nutritional, cultural, and economic importance for Indigenous peoples that improve individual and community health (Deur et al., 2015; Donatuto, 2008). Clam gardens support access to these nutritional, cultural, and economic benefits by providing interactions with the land, knowledge sharing between elders and youth, practice of traditional knowledge and culture, and a method for ecosystem stewardship. Clam garden activities specifically support community health by improving food security, autonomy, and cohesion (Augustine & Dearden, 2014; Deur et al., 2015; Donatuto, 2008; Groesbeck et al., 2014). For clams, the habitat created by clam gardens along with maintenance and harvesting activities help improve clam productivity, density, biomass, and recruitment (Deur et al., 2015; Groesbeck et al., 2014; Jackley et al., 2016). The improvements to animal health are not limited to clams. Other aquatic and terrestrial species are in greater abundance due to clam gardens, which provide new and improved habitat (Deur et al., 2015; Lepofsky & Caldwell, 2013). These health connections demonstrate the importance of the clam garden project and provide great opportunity to simultaneously improve health for

Indigenous people, clams, and the aquatic ecosystem. However, these connections also mean that a threat to one level of health may prevent or reverse the multitude of clam garden health benefits if risk management is not conducted in consideration of overall and holistic health.

Since the CSSP focuses only on the negative health consequences associated with shellfish consumption, the program is not balancing the positive and negative health outcomes threatened by PSP. This imbalance is also contrary to the Canadian Government's framework on precautionary risk management that recommends consideration of broad costs and benefits of decisions to confer net benefits to the public (PCO, 2003).

Does the approach have equitable distribution of risk and risk avoidance behaviour?

There are two main ways to examine distribution of risk; first, to determine where the threats (i.e. PSP-toxins) are more likely to occur; and second, where risk-taking behaviour (i.e. shellfish harvesting for consumption) is more likely to occur. Cases in the literature that discuss inequality in risk distribution often involve anthropogenically caused threats (i.e. landfills, harmful chemicals, polluting industrial facilities) (Agyeman, 1990; Brulle & Pellow, 2006b; Bullard, 1996; Bullard & Wright, 1993; Checker, 2007; Checker, 2002; Loring et al., 2010). PSP is caused by naturally occurring toxins; however, there are human factors that can increase the potential for HABs that may produce PSP-toxins, for example, sources of nutrients causing eutrophication, and ballast water (Al-Ghelani et al., 2005; DFO, 2015; Dolah, 2000; Halstead & Schantz, 1984). Whether shellfish harvesting areas for Indigenous communities are at greater risk than non-Indigenous areas, purposely or not, of factors that support HABs and PSP-toxins is unknown, and its investigation is beyond the focus of this paper. However, such a scenario would not be unheard of since there are many examples in the literature of situations where Indigenous communities bear an unequal level of risk for various environmental contaminants (for example, Dhillon & Young, 2010; Hanrahan, 2003; Mascarenhas, 2007). A study was conducted to analyze CFIA data from 2002-2012 to determine occurrences of PSP-toxins in coastal BC waters. It found that:

1) more harvesting sites exceed acceptable limits of PSP in warmer (May-October) than colder (November to April) months;

2) PSP-toxins are found in higher levels mostly along the northwest coast of BC (specifically, DFO Areas 4,6,9,10,11, and 23 (see figure 3.2.));

3) 6.1% of shellfish samples from 2002 to 2012 (n=33,376) exceeded acceptable saxitoxin levels (BCCDC, 2013).

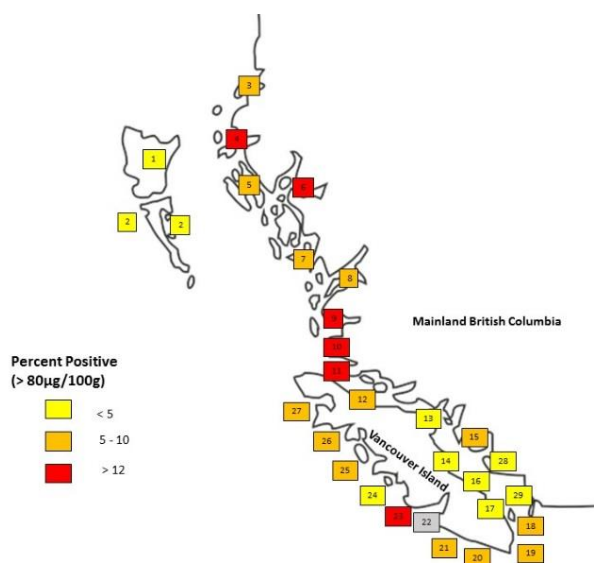


Figure 3.2. PSP-toxin above acceptable levels in Coastal British Columbia DFO Management Areas from 2002-2012 (BCCDC, 2013).

To determine the distribution of risk-taking behaviour, research would be required that identifies where shellfish harvesting activities are conducted and how Indigenous harvesting locations compare to non-Indigenous groups along the BC coast. However, a simple comparison between Indigenous and non-Indigenous harvesting areas is difficult since boundaries are not easily defined, and areas are often shared between the two groups. Information on shellfish harvesting and threats has not currently been collected and organized in a way to address these questions (DFO employee, personal communication, December 10, 2018). The process to do so and the associated evaluation is beyond the scope of this paper.

There is however, evidence suggesting inequities in risk avoidance behaviour. Even though the rules and regulations of the CSSP extend equally across the country, the design and implementation of the program incites inequities (CFIA, 2019). For example, there are inequities between DFO areas that have and do not have biotoxin monitoring. Areas that do have monitoring are only closed when evidence suggests unacceptable biotoxin levels are imminent (CFIA, 2019), but unmonitored subareas, such as 18-10, are permanently closed in a precautionary manner to prevent exposure to biotoxins.

The process to obtain an opening in an unmonitored subarea also has challenges (see section 3.3.4. for a description of the process). Three practical problems associated with this system are first, samplers may not be able to obtain the desired quantity of the target species at the harvesting location if the species is relatively rare; second, difficulty shipping samples from remote harvesting areas; and third, difficulty obtaining samples due to unfavorable tides (ECCC employee, personal communication, December 6, 2018; Parks Canada employee, personal communication, November 30, 2018). For example, opening dates are usually chosen for clam harvesting to coincide with low tides; thus, sample collection would be attempted a few weeks before the low tide when sampling is more challenging. Considering the process requires several

weeks, harvesting groups should be well organized, making their request to CFIA a few weeks in advance of the desired opening date, and should try to build strong professional relationships with relevant CFIA and DFO employees (Parks Canada employee, personal communication, November 30, 2018).

3.5.2. Participation

Does the approach include both state-led and place-based approaches to risk management? Does it include meaningful participation and collaboration with the affected people in defining, assessing, and managing risk?

PSP is managed using the CSSP, which only involves federal agencies. The CSSP has legal authority through several federal Acts and Regulations to design, implement, and enforce PSP risk management (CFIA, 2019). This level of power makes the CSSP the only recognized means to manage PSP within governmental and legal frameworks. The CSSP manual does not involve place-based approaches to risk management and has no requirement for participation and collaboration with affected people (CFIA, 2019). Indigenous communities are being engaged in CSSP delivery in specific regions (ECCC employee, personal communication, December 6, 2018); however, it is difficult to determine the level and amount of participation since documentation is not easily accessed. Currently, not all Indigenous communities have reached a desired level of participation within the CSSP. For example, the HTG want to have more authority over intertidal resource management in the belief that they can improve management and conservation efforts, and to maximize community benefits from shellfish harvesting. They also desire greater participation in DFO management plans and believe that the government excessively restrains shellfish harvesting (HTG, Evans et al., 2005). Indigenous peoples, like other resource users, have a direct connection to the decision-making process and CSSP representatives through the PRISC. Resource-users are permitted to attend biannual meetings where concerns can be raised that can help direct policy development and program implementation (ECCC employee, personal communication, December 6, 2018).

3.5.3. Characteristics

Does the approach support the affected people to flourish in the lives they choose for themselves, within ecosystem limits?

The CSSP supports the affected Indigenous communities in the sense that the program is trying to prevent physical illness from exposure to PSP-toxins that would decrease one's ability to thrive (CFIA, 2019, 2016). However, without meaningful collaborative participation with Indigenous communities, the participating federal agencies remain unaware of what lives the Indigenous communities want to live, and what type of PSP management system supports communities to flourish. For example, to the Hul'qumi'num people, flourishing means many things. In part, they want a future where their "land and sea resources are abundant and healthy" and their communities are "vibrant and strong" (HTG et al., 2005, p.22). They want a future that includes healthy beaches and rivers that support aquatic foods and are clean from pollution and contamination. Furthermore, they want a future where damaged resources are restored and measures are in place to prevent abuse and over-use (HTG et al., 2005).

The current system for risk management may prevent communities from flourishing by potentially unnecessarily restricting shellfish harvesting from limited biotoxin sampling and resulting precautionary measures. These potential unnecessary restrictions limit the possible benefits for the Indigenous communities, animals, and the ecosystem (see section 3.5.1. and chapter 2). As previously mentioned, there are regional specific efforts to accommodate and collaborate with Indigenous peoples, and Indigenous peoples can raise concerns at PRISC meetings (ECCC employee, personal communication, December 6, 2018).

Does the current approach support Indigenous capabilities for environmental justice (i.e. sovereignty, self-determination, and connections with the land)?

The CSSP manual has no mention of Indigenous people or any actions recommended to accommodate Indigenous capabilities to support EJ in the risk management process. The CSSP manual is mandated across Canada; however, it serves as a base where variability and flexibility are permitted in addition to the manual to address region specific issues (ECCC employee, personal communication, December 6, 2018). I was unable to retrieve documentation regarding special considerations in Indigenous sovereign territories to determine whether the CSSP supports Indigenous capabilities for EJ. The lack of acknowledgement of Indigenous peoples in the CSSP manual suggests that their rights to self-determination and autonomy are not being considered at the national level. Thus, Indigenous people are not free at the national level to determine their economic, social, and cultural development related to shellfish harvesting under the threat of PSP. The CSSP does not prevent Indigenous connections with the land, for example through clam gardens; however, it interrupts important components of land interaction, i.e. shellfish harvest and consumption. This interruption may be warranted when toxins causing PSP are present in harvesting areas. Unfortunately, selective biotoxin monitoring and resulting precautionary risk management cause potentially unnecessary closures of harvesting areas (CFIA employee, personal communication, March 16, 2018). Unnecessary closures prevent land connections through legal shellfish harvesting, may encourage illegal shellfish harvesting, and may cause shellfish avoidance by Indigenous people because of a perception of a greater than actual threat (Arquette et al., 2002; Donatuto, 2008; Loring & Duffy, 2011; Loring, Duffy, & Murray, 2010; Trainor et al., 2009). Needless avoidance prevents the benefits of shellfish harvest and consumption, and can potentially incite other health issues (see chapter 2) (Donatuto, 2008; Loring & Duffy, 2011).

Does the approach provide a process for re-evaluating decisions that includes follow-up research and monitoring in collaboration with the Indigenous communities?

The CSSP manual indicates that it is regularly reviewed by CFIA, ECCC, and DFO and amended as necessary to remain up to date. The National Interdepartmental Shellfish Committee (NISC) coordinates discussion and approval of amendments between RISCs and the headquarters of CFIA, ECCC, and DFO. There have been four amendments to the manual since its conception in 2012 and the manual was updated in 2019 to account for the new Safe Food for Canadians Act and Regulations (CFIA, 2019). No information could be found regarding the number of rejected amendments, source of recommended amendments, and difficulty level of the

amendment approval process. Nevertheless, this amendment process could be an important entry point for addressing some of the issues noted in this paper.

The CSSP does involve regular monitoring of biotoxins in a portion of the DFO subareas. This is done to inform decisions regarding area closures for shellfish harvesting to prevent human contamination with PSP-toxins. Monitoring is conducted by CSSP-mandated Government of Canada employees unless an agreement or contract is established between the Government of Canada and a non-government sampler. Such arrangements require non-government samplers to follow strict procedures for results to be accepted, and CSSP partners determine sampling procedures and the number of non-government sampling arrangements (CFIA, 2019). In areas where the shellfish harvesting industry is most active in BC, industry partners conduct the majority of sample collection, which are then sent to CFIA approved laboratories. Also, on the west coast and northern portions of Vancouver Island, First Nations have contracts with CFIA to conduct sample collection (DFO employee, personal communication, December 6, 2018). Furthermore, although community-based monitoring is not mentioned in the CSSP manual, it is supported by the CSSP when possible. There are several successful Indigenous-led projects that facilitate shellfish openings, for example, programs with Tsleil-Waututh and Becher Bay First Nations (ECCC employee, personal communication, December 6, 2018). However, not all First Nations involved in shellfish harvesting are sampling partners or are involved in a community-monitoring program. For example, the HTG wants to decrease harvesting areas under closure by having regular sampling and monitoring programs that include collaboration with Hul'qumi'num member First Nations on training and sampling, and data analysis that includes local interpretation (HTG et al., 2005).

3.5.4. Knowledge influencing decision-making

Does the approach consider traditional Indigenous knowledge along with Western scientific knowledge for decision-making?

The CSSP relies solely on Western scientific knowledge to fulfill its goal to protect Canadians from the “health risks associated with the consumption of contaminated bivalve molluscan shellfish” (CFIA, 2016). Area closures related to PSP are dependent on whether biotoxin levels are below, and not trending towards, levels considered unsafe for human consumption (saxitoxin levels must be $< 80 \mu\text{g}/100 \text{ g}$) (CFIA, 2019). This value was determined using Western scientific methods in the 1930s. Sommer and Meyer (1937) injected a defined amount of PSP-toxin extract from shellfish into mice and recorded mice death times (Sommer & Meyer, 1937). The exact reason scientists and regulators determined that $80 \mu\text{g}/100 \text{ g}$ of toxin should be the cut-off limit is unknown, but most likely involved mice death times and equipment sensitivity. There have been no reported human cases of PSP in properly tested shellfish with toxin levels below this limit (Wekell et al., 2004). Over time, high-performance liquid chromatography has replaced mice for determining biotoxin levels (ECCC employee, personal communication, December 6, 2018).

In the absence of biotoxin monitoring, area status is risk managed using biotoxin monitoring information from surrounding subareas to influence an opening and to determine the length of the opening. This risk extrapolation is based on Western scientific knowledge (CFIA

employee, personal communication, March 16, 2018). Furthermore, the CSSP manual does not reference use of any other type of knowledge, including Indigenous traditional knowledge in the design and implementation of PSP risk management (CFIA, 2019). Many coastal Indigenous communities used traditional knowledge to understand where and when shellfish were the safest to harvest to protect against contaminated shellfish consumption. For example, Moss and Wellman (2017) used place names found in Boas (1909) to illustrate Indigenous knowledge of places more commonly containing contaminated shellfish, for example, *dzo'dzade* “having clam poisoning” and *ku'nxade* or *kwe'kungade* “having rotten clams”. The authors use this information to demonstrate the specific geographical knowledge the Kwakwaka'wakw used to determine where clams were safe to eat, and perhaps where clam gardens were best located. Furthermore, Deur et al. (2015) described how the Kwakwaka'wakw traditionally only harvested clams in the winter to protect against consumption of shellfish contaminated from harmful algal blooms.

Table 3.2. Summary of application of the framework on environmental justice related to risk management on the CSSP			
Does the risk management system...	Hypothetical example in the context of Indigenous shellfish harvesting and PSP	Summary of the Canadian Shellfish Sanitation Program	References
Include and consider local Indigenous culture, experiences, spirituality, and economics in the context of the colonial legacy?	Indigenous communities involved in shellfish harvesting are consulted to understand their traditional and current relationships with shellfish harvesting, and how these relationships are impacted by PSP.	<ul style="list-style-type: none"> No indication in manual that Indigenous culture, experience, spirituality, and economics were considered Some regional specific efforts (e.g. siphon removal) 	(CFIA, 2019; ECCC employee, personal communication, December 6, 2018)
Consider benefits and dangers perceived by the affected people?	Indigenous communities involved in shellfish harvesting are consulted to determine what they consider to be the benefits of shellfish harvest and consumption, the dangers associated with PSP, where they believe the balance between benefits and dangers should exist, and what is an acceptable level of risk.	<ul style="list-style-type: none"> Focuses only on negative health consequences associated with shellfish consumption No indication in manual that collaboration with affected people occurs Concerns can be raised at PRISC meetings 	(CFIA, 2019; ECCC employee, personal communication, December 6, 2018)
Have equitable distribution of risk and risk	Indigenous shellfish harvesting locations have an equal threat-level of	<ul style="list-style-type: none"> Comparison of risk level and risk-taking behaviour density 	(CFIA, 2019; ECCC employee,

avoidance behaviour?	PSP compared to shellfish harvesting areas for non-Indigenous peoples. Indigenous communities involved in shellfish harvesting are required to have an equal level of risk avoidance behaviour from PSP and the risk management system as other shellfish harvesting groups.	<p>between Indigenous and non-Indigenous shellfish harvesting areas relating to PSP is unknown and beyond the scope of this paper</p> <ul style="list-style-type: none"> • Unmonitored areas for biotoxins require greater risk avoidance compared to monitored areas 	personal communication, December 6, 2018; Parks Canada employee, personal communication, November 30, 2018)
Include both state-led and place-based approaches to management?	The Canadian Government and Indigenous communities involved in shellfish harvesting are collaboratively involved in PSP risk management.	<ul style="list-style-type: none"> • PSP is managed using the CSSP, which only involves federal agencies • Indigenous communities are being engaged in CSSP delivery only in specific regions • Concerns can be raised at PRISC meetings 	(CFIA, 2019; ECCC employee, personal communication, December 6, 2018)
Include meaningful participation and collaboration with the affected people in defining, assessing, and managing risk?	The Government of Canada collaboratively participates with Indigenous communities involved in shellfish harvesting to define, assess, and manage PSP risk. Indigenous perspectives are included in risk management systems.		
Support the affected people to flourish in the lives they choose for themselves, within ecosystem limits?	The PSP risk management system protects against PSP, while supporting development and long-term success of Indigenous shellfish harvesting.	<ul style="list-style-type: none"> • Trying to prevent physical illness from PSP-toxins • Unaware of what lives the Indigenous communities want to live in areas without collaboration • May prevent communities from thriving when unnecessary restrictions are placed on shellfish harvesting 	(CFIA, 2016, 2019; chapter 2)
Support Indigenous capabilities for	The PSP risk management system works within the sovereignty of First	<ul style="list-style-type: none"> • The manual has no mention of Indigenous people 	(Arquette et al., 2002; CFIA, 2019;

environmental justice (i.e. sovereignty, self-determination, and connections with the land)?	Nations and respects and includes Indigenous government's decisions related to their traditional territories. The cultures, traditions, and ways of life of Indigenous communities involved in shellfish harvesting are respected, considered, and supported in PSP risk management	<ul style="list-style-type: none"> • Preventing shellfish consumption, particularly when unwarranted, prevents connections with the land, may encourage illegal shellfish harvesting, and may cause unnecessary shellfish avoidance <ul style="list-style-type: none"> ○ Needless avoidance may incite other health issues 	Donatuto, 2008; Loring & Duffy, 2011; Loring et al., 2010; Trainor et al., 2009)
Provide a process for re-evaluating decisions that includes follow-up research and monitoring in collaboration with the Indigenous communities?	The PSP risk management system is periodically re-evaluated in collaboration with Indigenous communities involved in shellfish harvesting with the goal to maximize protection against PSP, while supporting Indigenous shellfish harvesting. Indigenous communities participate in the research and monitoring that supports the PSP risk management system.	<ul style="list-style-type: none"> • Manual is regularly reviewed and updated by CFIA, ECCC, and DFO • Recommendations for amendments can be made by external parties • Regular monitoring for biotoxins occurs in select areas • Monitoring is conducted by CSSP-mandated employees or other parties when provided permission by the CSSP • There are some community-based monitoring agreements with Indigenous communities 	(CFIA, 2019; ECCC employee, personal communication, December 6, 2018)
Consider traditional Indigenous knowledge along with Western scientific knowledge for decision-making?	Indigenous knowledge from Indigenous communities involved in shellfish harvesting is considered along with Western scientific knowledge in the design, implementation, and re-evaluation of the PSP risk management system.	<ul style="list-style-type: none"> • Relies solely on Western scientific knowledge 	(CFIA, 2019)

3.6. DISCUSSION

Considering the literature on risk and EJ and the results of the framework application, there are three main improvements that can be made to the CSSP to help increase EJ for Indigenous shellfish harvesters. First, creation of a collaborative body involving First Nations to explore opportunities and methods to improve Indigenous participation in PSP risk management. Collaboration will help the CSSP develop a more inclusive characterization of health, risks, benefits and dangers associated with risk taking, and how the CSSP can be designed to promote thriving communities. This may help the CSSP move from a system designed to prevent harm to one that also promotes health.

Second, exploring opportunities to expand and/or modify monitoring. CSSP members are currently investigating alternative biotoxin monitoring methods available through technological advancement, which may permit more widespread, cost-effective, and inclusive monitoring (ECCC employee, personal communication, December 2, 2018). Expansion of community-based monitoring programs may also be desirable. Community-based monitoring has many benefits including enhancing community cohesion; promoting sustainable development; improving trust between partners and in results; and increasing individual and community engagement and interest in ecosystem management, local planning, decision-making, and policy direction. Concerns with community-based monitoring include data inaccuracies and fragmentation, loss of community interest, and inconsistent funding (Pollock & Whitelaw, 2005). Some of these issues can be managed under the current system by issuing monitoring contracts to interested Indigenous communities, providing or requiring adequate resource availability, collaborating to determine best monitoring techniques that produce desired data quality, and supporting training. A community-based monitoring program independent or outside of the current PSP management system may be desired. There are several types of participation and approaches to community-based monitoring with varying advantages and disadvantages depending on individual circumstances (see Conrad & Hilchey, 2011). The most environmentally just program would be developed in collaboration with all affected parties.

Third, exploring opportunities to use Indigenous traditional knowledge as a collaborating knowledge source alongside Western science. This knowledge expansion may help better understand the risk and best practices for risk management.

It should be noted that the evaluation of the CSSP in this paper is mainly focused on the CSSP manual. There are efforts in addition to the manual that attempt to improve region-specific issues, including having collaborative participation with Indigenous peoples (ECCC employee, personal communication, December 6, 2018). The CSSP manual should be updated to account for these efforts and regional variations, at least by providing direction to where additional information can be obtained.

It should also be noted that the CSSP was created before the TRC; however, it was updated in 2019 without noticeable inclusion of TRC recommendations. The TRC was established as part of the Indian Residential School Settlement Agreement to document and educate Canadians about the residential school experience and legacy, and develop recommendations on how the country can embrace reconciliation (TRC, 2015b). The calls to

action highly stress the need to implement the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), which identifies several considerations affecting Indigenous EJ (TRC, 2015a; UN, 2007). Articles 3-5 and 20 of the UNDRIP recognize Indigenous peoples' right to self-determination to have autonomous freedom over their politics, economy, and social and cultural development. Articles 11, 25, 26, and 29 discuss the rights of Indigenous peoples to their traditional and more recently acquired lands. These rights comprise the protection and conservation of the environment and control over resources in their territories, and to practice and revitalize their cultural traditions including strengthening their spiritual connection with the land. Articles 8, 19, 26, and 27 address responsibilities of the State which include: providing mechanisms to prevent any action that aims to or results in dispossessing Indigenous peoples from their lands and resources; legally recognizing and protecting Indigenous rights to their lands; developing a process to manage Indigenous land rights, which involves the right of Indigenous peoples to participate in the process; and working collaboratively in good faith with Indigenous peoples to obtain free, prior, and informed consent before establishing measures that impact Indigenous affairs (UN, 2007). Therefore, key elements to an update supporting the TRC recommendations would be for the CSSP to respect Indigenous peoples' rights to self-determination, autonomy, and control over their lands. This recognition would foster more collaboration with Indigenous communities and respectful inclusion of their wants into development of the risk management system.

There will of course be constraints on the CSSP for implementing the changes recommended in this paper, for example, availability of finances and resources, and variability in opinions, needs, and desires among Indigenous communities. However, collaboration is essential for all groups to understand the goals and limitations of the others, and to develop a way forward that achieves the greatest benefits.

Understanding there are changes to the CSSP that would improve EJ, there are six main actions Indigenous communities can take under the current system to help improve some EJ-related issues. First, Indigenous communities can apply to the RISC for a new harvesting area classification under the CSSP where Indigenous shellfish harvesting occurs (CFIA, 2019). This may help the CSSP better understand activities and concerns related to Indigenous shellfish harvesting. Second, Indigenous shellfish harvesting that occurs outside areas monitored for biotoxins can apply for monitoring to occur in their DFO subarea. Since monitored areas are chosen based on several factors including the amount of shellfish harvesting activity in a given area, the CSSP may be unaware that another harvesting activity requires consideration in PSP monitoring decision-making (CFIA, 2012). Third, the Indigenous community can apply under the CSSP to be a monitoring partner in their area or make a recommendation for a community-based monitoring program. This application could act as a bridge to help increase collaboration between the CSSP and Indigenous communities. Fourth, Indigenous communities can draft one or more amendments to the CSSP. Indigenous-led amendments can help direct changes towards a more environmentally just risk management system and increase education for CSSP members about Indigenous desires and needs. Fifth, Indigenous shellfish harvester representatives can attend PRISC meetings to raise concerns, communicate directly with CSSP representatives, and gain more knowledge about the CSSP. Finally, Indigenous communities should attempt to build

strong professional and working relationships with relevant employees in the CSSP to help navigate the system.

There are many barriers to shellfish harvesting with some being unique to Indigenous peoples and others shared by all harvesters. Barriers for Indigenous peoples include: environmental health issues; land, water, and resource dispossession and privatization; inadequate consultation and rejection of Indigenous territorial rights; management and enforcement structures imposed by non-Indigenous governments; inadequate resources and poverty; and lack of traditional knowledge (Fediuk & Thom, 2003; HTG et al., 2005; Silver, 2014). Of the environmental contaminants, PSP is only one of many that are risk managed under the CSSP where distinct approaches and standards are applied to different contaminants. Although beyond the scope of this paper, an investigation of the impacts of risk management on harvesters for other environmental contaminants is needed. This will help determine areas of improvement for managing individual threats and the CSSP as a whole.

3.7. CONCLUSION

The current system to manage risk associated with PSP in Canada is the CSSP, which is designed and implemented by three federal agencies. The program is focused on preventing human exposure to PSP from consuming contaminated shellfish (CFIA, 2019, 2016). Generally speaking, exposure is prevented by monitoring biotoxin levels in shellfish in selected areas, and closing areas for shellfish harvesting when results suggest biotoxin levels will exceed acceptable levels, or when levels are unknown (CFIA, 2019; CFIA employee, personal communication, March 16, 2018).

Although preventing exposure to PSP-toxins is very important since they can cause illness and death, some of the methods used by the CSSP could be improved or modified to better support EJ for Indigenous shellfish harvesters (DFO, 2015; Halstead & Schantz, 1984). Improvements include: increasing meaningful collaborative participation with affected people; expanding and/or modifying monitoring, including increasing opportunities for community-based monitoring; using Indigenous traditional knowledge alongside Western science to inform decision-making; and recognizing Indigenous peoples' rights to self-determination and autonomy. These steps would improve risk management; inclusive and informed decision-making; respect for Indigenous sovereignty, self-determination, and connections with the land; distribution of risk and risk avoidance behaviours; and knowledge expansion. Greater inclusion and respect are also more likely to improve compliance with risk management systems, create greater trust between groups, and help build capacity.

In addition to these recommended changes to the CSSP, Indigenous communities can also take steps under the current system to improve EJ. These steps include creating and submitting draft amendments for the CSSP; attending PRISC meetings and developing strong working relationships with CSSP members; and applying under the CSSP for new area classification, monitoring sites, and to be monitoring partners in areas where shellfish harvesting occurs.

My evaluation of PSP risk management in Canada has determined that the current system needs modifications to be more supportive of EJ for Indigenous shellfish harvesters. I hope my investigation can be used to identify areas of improvement in the CSSP and actions Indigenous communities can take to help make the system more environmentally just for shellfish harvesters. Although my investigation was limited to PSP and Indigenous shellfish harvesters, the framework can be used to assess EJ related to management of other threats to Indigenous shellfish harvesters, and/or other traditional Indigenous activities. Even though the framework and evaluation were Indigenous focused, some of the findings and recommendations are pertinent to non-Indigenous shellfish harvesters, particularly those related to local collaborative participation.

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4. CONCLUSION

The examination of the connections related to Indigenous shellfish harvesting practices and the impacts of threats and risk management systems on these practices, provides an interesting example of the benefits and challenges of restoring traditional land interactions within a colonialized framework. Even with a current federal government that at least verbally identifies its commitment to reconciliation, Indigenous peoples are still forced to function within a colonial system (Liberal Party of Canada, 2015). The TRC provides direction on how to change and help navigate the system; however, its recommendations have not yet been fully realized and implemented by the Government of Canada. My research promotes and demonstrates how different ways of thinking can improve the current system to help break down barriers faced by Indigenous peoples and move towards reconciliation. Concepts important to this different way of thinking are health, risk, and EJ, particularly for Indigenous peoples.

The concept of health has generally moved beyond a focus on physical wellness to also include mental and physical well-being (WHO, 1948). The Indigenous concept of health takes health further, understanding humans as interconnected and inseparable from all else through physical, emotional, intellectual, and spiritual connections. Thus, health is viewed concurrently with community, animals, and the environment using knowledge transmission and cultural practices to understand the past, present, and future (CSDH, 2007; Donatuto, 2008; King et al., 2009). The One Health framework can work with Indigenous health and is beneficial to understanding traditional practices since it models the interdependence of human, animal, and ecosystem health (Lapinski et al., 2015; Wolf, 2015). A holistic approach to OH also embraces the wider definition of health and includes consideration of food security, economics, community participation, and social behaviours in understanding health connections (OH congress, 2011; Hinchliffe, 2015; Hueston et al., 2013). An important aspect of health that is often overlooked is that the concept of health is often place-based and can vary between different cultures and communities (Charlier et al., 2017; Hinchliffe, 2015; King et al., 2009). Therefore, when dealing with health or exploring health connections, investigators should develop an understanding of the local perception of health to gain more accurate and relevant results.

Risk and health share similarities and are often considered in conjunction since they are both place-based and influenced by culture. The perception of probability of undesired outcomes is subjective and strongly rooted in cultural and social experiences (Adams, 1995; Checker, 2007; Donatuto, 2008; Loring & Duffy, 2011). Assessing where the balance should exist between the benefits and dangers of a risk and then determining what risks are worth taking is also influenced by very individual or community-based factors (Adams, 1995; Davidson & Freudenburg, 1996; Donatuto, 2008; Drake, 1992; Flynn et al., 1994; Johnson, 1991). Although society generally has been convinced to desire a state of minimal or zero risk, there can be many benefits to risk taking (Adams, 1995; Arquette et al., 2002; Donatuto, 2008; Loring & Duffy, 2011). There are also many ways to understand risk including Western science and Indigenous traditional knowledge. Consequently, for risk management to be appropriate, effective, and just, it should include a participatory process with the people being affected by the risk acting alongside state-level management.

Many have recognized the connection between risk management and justice well before the start of the EJ movement. Environmental degradation is often connected to equality, rights, social justice, and/or quality of life, and the movement began to battle the unequal distribution of environmental risks and risk avoidance behaviour to disadvantaged demographic groups by industry and governments (Agyeman et al., 2002; Bullard, 1996, 2001; Bullard & Wright, 1993; Checker, 2007; Loring & Duffy, 2011; O'Neil, 2003; Schlosberg, 2004; Schlosberg & Carruthers, 2010). In addition to distribution, EJ also includes recognition of diversity in people and experiences, participation in environmental policy creation and management, and supporting people to flourish in the lives they choose for themselves while respecting environmental limits (Agyeman et al., 2002; Schlosberg, 2004; Schlosberg & Carruthers, 2010).

Indigenous EJ, while sharing these qualities with other minority groups, also involves several unique characteristics. The unique position of Indigenous peoples as first peoples means EJ also includes the right of self-government and sovereignty protection (O'Neil, 2003; Tsosie, 2007). Information in the UNDRIP, recommended to be implemented by the TRC, suggest that Indigenous EJ also includes the right of Indigenous peoples to their lands, self-determination, practice and development of culture, and participation in decision-making affecting their lives (UN, 2007). Recognition that EJ as a framework needs to be expanded to fully account for the issues facing Indigenous peoples is a noteworthy contribution of this research that could be explored in future work.

There can be several benefits to this different way of thinking. For example, embracing an expanded understanding of health, risk, and EJ would encourage changes to how risk management systems are designed and implemented. Ideally, risk management systems would be a place-based process including collaborative participation with those affected by the risk and higher levels of government. These systems would consider different perceptions of and knowledge related to health and risk, management would promote better lives for the people, and risk distribution would be more equitable. Risk management systems that adopt these measures will hopefully help move the process from one that aims to prevent harm to one that also promotes health.

My research contributes to this different direction for risk management systems by examining the case of PSP risk management related to EJ for Indigenous shellfish harvesters in BC. Although revealing helpful information related to this topic, my research also identifies five main gaps in the current research. First, my research was conducted from an outsider perspective, based mostly on the current literature. While a useful first step, Indigenous peoples involved in clam gardens and other shellfish harvesting activities should be consulted to gain their direct impressions on health connections in clam gardens and EJ related to PSP risk management.

Second, other threats to shellfish harvesting, such as other environmental contaminants, should be examined more closely under an EJ lens. Other contaminants managed under the CSSP that would benefit from further investigation include sanitary contaminants, other microbes and viruses, and heavy metals. In addition to marine biotoxins, sanitary contaminants in particular also represent a major cause of area closures to shellfish harvesting (DFO, n.d.).

During my research, several individuals raised the question of whether Indigenous shellfish harvesting areas are disproportionately located in proximity to sources of sanitary contamination, such as waste water treatment facilities, compared to non-Indigenous shellfish harvesters. Although this question deserves attention, investigation was beyond the scope of my research.

Third, distribution of risk should be examined more thoroughly including where risks and risk-taking behaviour are more likely to occur. As mentioned in chapter 2, further investigation is required to determine whether the level of PSP risk varies between Indigenous and non-Indigenous shellfish harvesting areas, and where shellfish harvesting, both Indigenous and non-Indigenous, are more heavily concentrated. This investigation could also be expanded beyond BC to include other coastal regions of Canada.

Fourth, a broader investigation of EJ is required for Indigenous peoples relating to situations involving traditional harvesting practices, self-determination, self-governance, and/or autonomy. These are key factors involved in the calls to action made by the TRC and the UNDRIP (TRC, 2015a; UN, 2007). This investigation should be framed to investigate risk management, but also other societal influences (e.g. policy creation and implementation, resource development, and international agreements).

Finally, some of the issues raised in my research are also relevant to non-Indigenous shellfish harvesters, particularly the local, smaller-scale harvesters. I believe it would be beneficial to examine health, risk, and EJ in a context and framework that concurrently considers both groups. This may be a way to help build relationships between Indigenous and non-Indigenous harvesters by considering issues relating to us instead of us and them, while also educating about the unique position of Indigenous peoples.

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